REVISION GUIDE

A cell of *rooms*

Organelles and compartmentalization

A eukaryote cell keeps its work in separate rooms. Find out what counts as an organelle and how they were first pulled apart, why the nucleus keeps its genes away from the ribosomes, what a lysosome is for, and at higher level how mitochondria, chloroplasts, the ER, the Golgi and vesicles are built for their jobs.

9 chapters

The interactive guide, with every animation:
biologybybradford.com/guides/ib-biology-b2-2-organelles-and-compartmentalization

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By the end you can

- [ ] Say which parts of a cell are organelles and which are not, and how cell fractionation let biologists study them one at a time B2.2.1
- [ ] Explain the advantage of separating transcription in the nucleus from translation in the cytoplasm B2.2.2
- [ ] Explain how compartments concentrate enzymes and substrates and keep incompatible processes apart, with lysosomes and phagocytic vacuoles B2.2.3
- [ ] Explain how the mitochondrion is adapted for making ATP by aerobic respiration B2.2.4
- [ ] Explain how the chloroplast is adapted for photosynthesis B2.2.5
- [ ] Explain the benefits of the double nuclear membrane, its pores, and its breaking into vesicles when a cell divides B2.2.6
- [ ] Contrast proteins made by free ribosomes with those made on the rough ER B2.2.7
- [ ] Describe how the Golgi apparatus processes proteins and sends them for secretion B2.2.8
- [ ] Describe how vesicles form and move, and the role of clathrin B2.2.9

Tick each one when you can do it without the book.

B2.2.1 ORGANELLES AS DISCRETE SUBUNITS OF CELLS THAT ARE ADAPTED TO PERFORM SPECIFIC FUNCTIONS

01 Rooms with *jobs*

An **organelle** is a discrete part of a cell with its own job and a structure that suits it. Most are wrapped in membrane: the nucleus, mitochondria, chloroplasts, the ER, the Golgi apparatus, lysosomes and vesicles. Two have no membrane but still count: ribosomes, and the plasma membrane itself.

Three things in a cell are not organelles. The **cytoplasm** is everything inside the membrane, organelles and all, so it is not one unit. The **cytoskeleton** is a network of fibres running through the whole cell, not a separate part. The **cell wall** lies outside the plasma membrane, made and laid down by the cell but not a working part inside it.

Biologists could only study what each organelle does once they could get it on its own. That came with the **ultracentrifuge** and **cell fractionation**: cells are broken in a cold buffer of the same concentration as the cell, then spun faster and faster. The biggest, densest parts settle first as a **pellet**; the liquid is poured into a new tube and spun harder. A new technique opened up a new field.

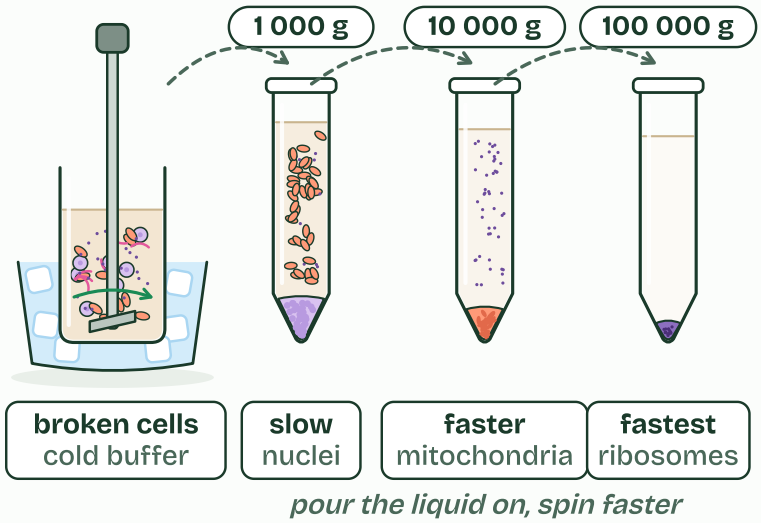
KEY POINTS

- Organelles: discrete subunits, each adapted to a job.
- Not organelles: the cytoplasm, the cytoskeleton, the cell wall.
- Fractionation separates organelles by size and density, spin by spin.

KEY TERMS

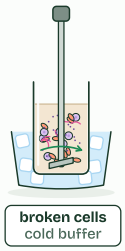
organelle
A discrete structure within a cell, adapted to carry out a particular function.

cell fractionation
Breaking cells open and separating their parts by spinning them in a centrifuge at increasing speeds, so that larger, denser parts settle first.



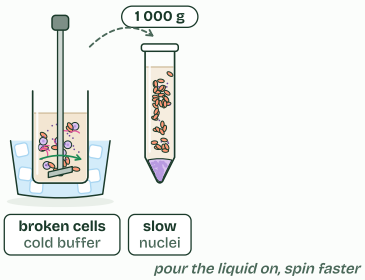
STEP BY STEP 4 STEPS

1



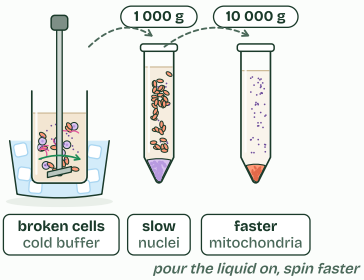
Cells are broken open in a **cold, isotonic buffer**. Everything is still mixed.

2



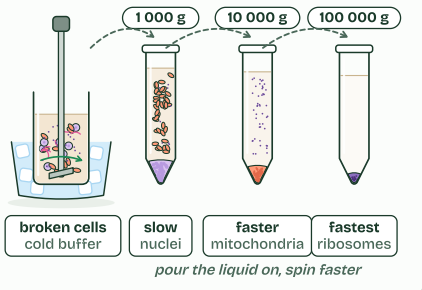
A slow spin: the biggest, densest parts, the **nuclei**, settle as a pellet.

3



The liquid goes into a new tube and is spun faster: now the **mitochondria** settle.

4



Faster still: the smallest parts, **ribosomes** and bits of membrane, come down last.

WATCH OUT

An organelle does not need a membrane round it. Ribosomes have none and are still organelles.

PREDICT

Why is the buffer used in fractionation kept ice cold and at the same concentration as the cytoplasm?

(A) Cold makes the organelles denser, so that they settle out faster when the tube is spun

(B) Cold slows enzymes that would digest the organelles, and the same concentration stops osmosis bursting them

(C) Cold keeps the centrifuge from overheating, and the same concentration keeps the tubes from cracking

Decide before you look. Answer on page 25.

B2.2.2 ADVANTAGE OF THE SEPARATION OF THE NUCLEUS AND CYTOPLASM INTO SEPARATE COMPARTMENTS

02 Genes behind a *wall*

To make a protein, a gene is first copied into mRNA, **transcription**, and the mRNA is then read by ribosomes, **translation**. In a prokaryote there is only one compartment. Ribosomes can latch on to an mRNA while it is still being made, so the two happen at once.

In a eukaryote the nuclear envelope keeps them apart: transcription in the nucleus, translation in the cytoplasm. That gap buys time. Before the mRNA leaves, it can be modified: stretches that do not code, **introns**, are cut out, and the ends are protected. Only the finished mRNA meets a ribosome, so the protein made is the right one.

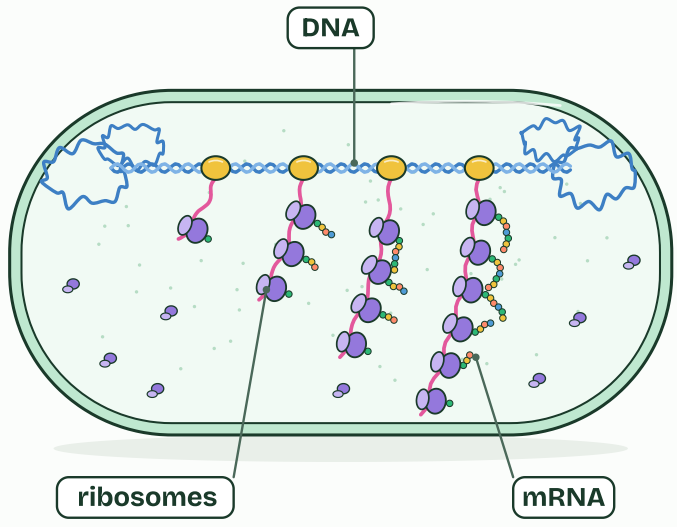
KEY POINTS

- Prokaryotes: transcription and translation together, in one compartment.
- Eukaryotes: transcription in the nucleus, translation in the cytoplasm.
- The separation lets mRNA be modified before it is translated.

KEY TERMS

introns
Sections of a gene and of its first mRNA copy that do not code for the protein and are cut out before the mRNA is translated.

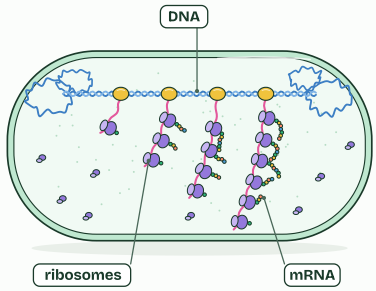
Translation starts while transcription goes on



SWITCH IT

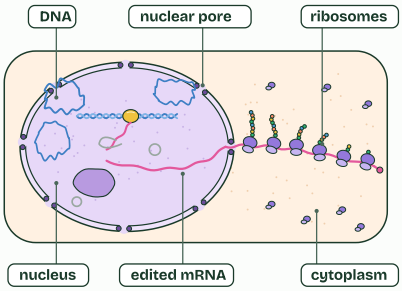
2 SETTINGS

1



Prokaryote

2



Eukaryote

WATCH OUT

The nucleus does not make proteins. It holds the genes and makes the mRNA; the proteins are made in the cytoplasm.

PREDICT

What could go wrong if ribosomes reached a eukaryote's mRNA before it left the nucleus?

(A) The ribosomes would damage the DNA, because they would bind to the genes as well as the mRNA

(B) The ribosomes would translate the introns too, making a faulty protein

(C) Nothing at all, because transcription and translation always give the same protein

Decide before you look. Answer on page 25.

03 Keep it *apart*, keep it close

B2.2.3 ADVANTAGES OF COMPARTMENTALIZATION IN THE CYTOPLASM OF CELLS

Membranes divide the cytoplasm of a eukaryote into compartments, and that helps in two ways. **Concentration.** Enzymes and the substances they act on are packed into a small space, so they meet more often and reactions run faster. **Separation.** Processes that would harm each other are kept apart, and each compartment can hold the conditions its enzymes need, such as a different pH.

Lysosomes show both. They hold digestive enzymes that could break down almost anything in the cell, at a pH of about 5, more acid than the cytoplasm. Loose in the cytoplasm the enzymes would digest the cell; inside the lysosome they are safe and concentrated. When a white blood cell takes in a bacterium, it wraps it in a **phagocytic vacuole**. Lysosomes fuse with the vacuole and their enzymes digest the bacterium there, away from the rest of the cell.

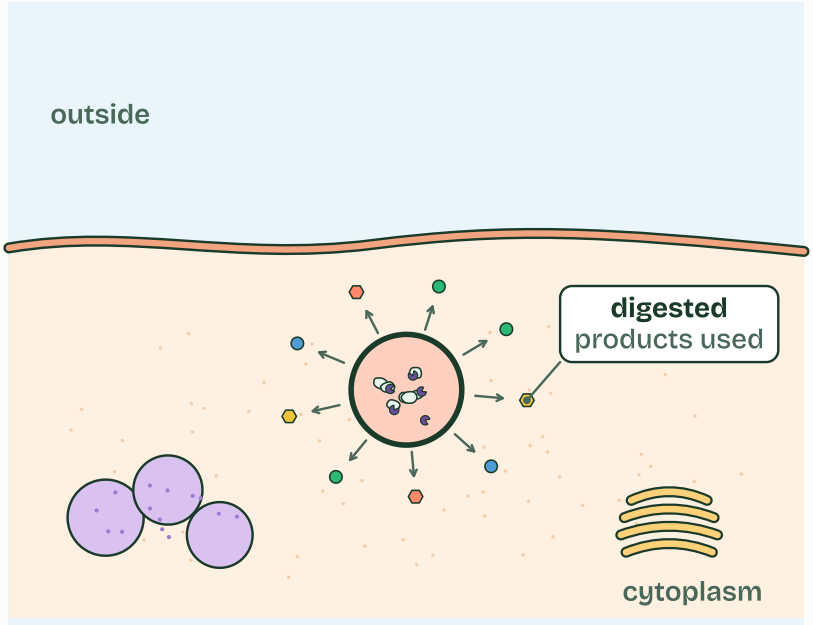
KEY POINTS

- Compartments concentrate enzymes and substrates: faster reactions.
- They keep incompatible processes and conditions apart.
- Lysosomes digest the contents of phagocytic vacuoles, sealed off from the cytoplasm.

KEY TERMS

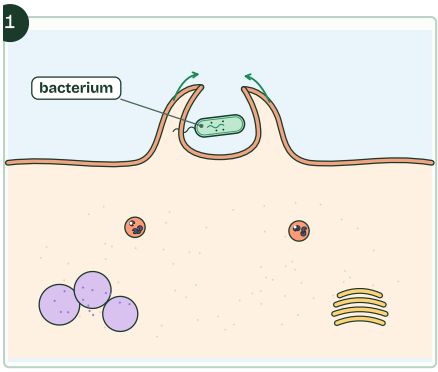
lysosomes
A small organelle bounded by one membrane, containing digestive enzymes that work best at an acid pH.

phagocytic vacuole
A vacuole formed when a cell engulfs a large particle, such as a bacterium, by phagocytosis.

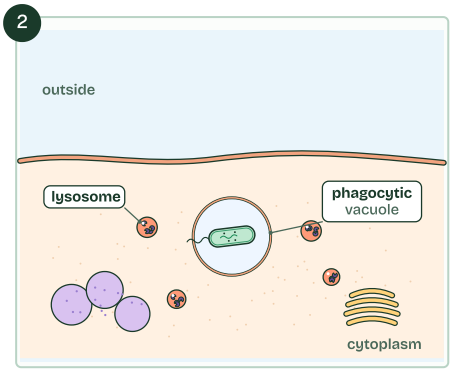


STEP BY STEP

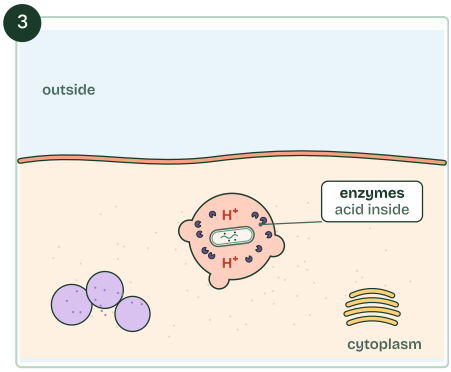
4 STEPS



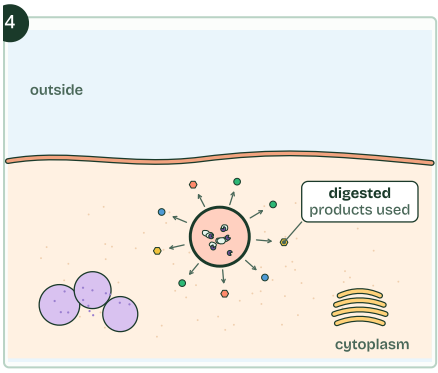
A white blood cell's membrane flows round a **bacterium**.



The bacterium is inside, in a **phagocytic vacuole**. Lysosomes are close by.



Lysosomes fuse with the vacuole, adding their enzymes in an acid compartment.



The bacterium is **digested**; the small molecules made are used by the cell.

WATCH OUT

Lysosomes do not release their enzymes into the cytoplasm to digest things. The enzymes stay inside membrane, in the lysosome or the vacuole it fuses with.

PREDICT

A lysosome leaks a little of its contents into the cytoplasm. Why does this do the cell little harm?

(A) The enzymes are used up at once, as they react with the first molecules they meet

(B) The cytoplasm has no molecules in it that the enzymes are able to digest at all

(C) The enzymes work best at an acid pH and are much less active at the pH of the cytoplasm

Decide before you look. Answer on page 25.

B2.2.4 HL ADAPTATIONS OF THE MITOCHONDRION FOR PRODUCTION OF ATP BY AEROBIC CELL RESPIRATION

04 The ATP *factory*

Most of a cell's ATP is made in its **mitochondria**, and their structure fits the job. A **double membrane** encloses them. Between the two membranes is a very small **intermembrane space**: protons are pumped into it, and because it is so small their concentration rises quickly, giving the steep gradient that drives ATP synthase.

The inner membrane is folded into **cristae**. The folds give a huge surface for the electron transport chains and the ATP synthase enzymes that sit in it. Inside is the **matrix**, a compartment that keeps the enzymes and substrates of the Krebs cycle together, so they meet often.

KEY POINTS

- Double membrane; a small intermembrane space for a steep proton gradient.
- Cristae: a large surface for electron transport and ATP synthase.
- Matrix: Krebs cycle enzymes and substrates kept together.

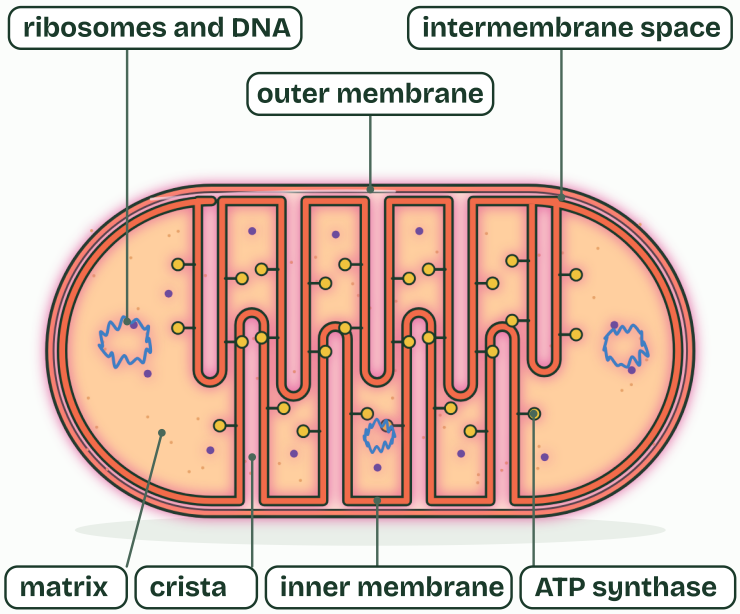
KEY TERMS

mitochondria
The organelle where the later stages of aerobic respiration take place, producing most of a eukaryote cell's ATP.

intermembrane space
The narrow space between the outer and inner membranes of a mitochondrion, into which protons are pumped during respiration.

cristae
The folds of the inner membrane of a mitochondrion, which give a large surface for electron transport chains and ATP synthase.

matrix
The fluid inside the inner membrane of a mitochondrion, holding the enzymes of the link reaction and the Krebs cycle.



Outer membrane and the **intermembrane space** The outer membrane wraps the whole organelle. The space between it and the inner membrane is very small, so the protons pumped into it during respiration build up a steep gradient quickly.

Inner membrane , folded into **cristae** The folds give a very large surface for the electron transport chains and ATP synthase that make most of the cell's ATP.

Matrix The fluid inside the inner membrane. It holds the enzymes and substrates of the link reaction and the Krebs cycle together in one small compartment, so they meet often and the reactions run fast.

Ribosomes (70S) and a loop of **DNA** The mitochondrion makes a few of its own proteins: a trace of its bacterial past.

WATCH OUT

Mitochondria do not make energy. They transfer energy from food to ATP.

PREDICT

Heart muscle cells have mitochondria with many more cristae than those of skin cells. Why?

(A) More cristae make the mitochondria stronger, so that they survive the heart's constant beating

(B) More cristae give more membrane for ATP synthase, and heart muscle uses ATP very fast

(C) More cristae make the matrix larger, so it can hold more glucose for respiration later

Decide before you look. Answer on page 25.

05 A stack of *solar panels*

B2.2.5 HL ADAPTATIONS OF THE CHLOROPLAST FOR PHOTOSYNTHESIS

A **chloroplast** also has a double membrane, and inside it a system of flattened sacs, the **thylakoids**, often in stacks called **grana**. The thylakoid membranes hold the **photosystems** that absorb light, so a large area of membrane means more light caught. The space inside each thylakoid is tiny, so protons pumped into it quickly build a steep gradient for ATP synthase, just as in the mitochondrion.

Around the thylakoids is the **stroma**, a compartment holding the enzymes and substrates of the **Calvin cycle**, with Rubisco the most plentiful. The light-dependent reactions on the membranes and the Calvin cycle in the stroma sit side by side, so ATP and reduced NADP pass straight from one to the other.

KEY POINTS

- Thylakoid membranes: a large surface for photosystems.
- A small volume inside each thylakoid: a steep proton gradient.
- Stroma: Calvin cycle enzymes and substrates kept together.

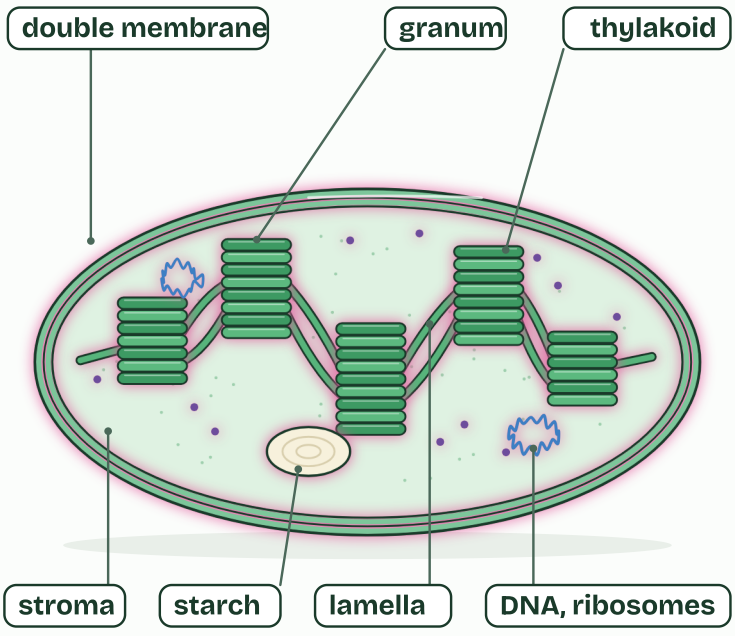
KEY TERMS

chloroplast
The organelle in plant and algal cells where photosynthesis takes place.

thylakoids
Flattened membrane sacs inside a chloroplast, whose membranes hold the photosystems and ATP synthase.

grana
Stacks of thylakoids in a chloroplast.

stroma
The fluid inside the inner membrane of a chloroplast, holding the enzymes of the Calvin cycle.



Stroma The fluid inside the inner membrane. It holds the enzymes and substrates of the Calvin cycle, Rubisco above all, together in one compartment.

Lamellae Single thylakoids joining one granum to the next, so the membrane system is all one.

Double membrane An outer and an inner membrane round the whole chloroplast, keeping the stroma's enzymes and substrates in.

Thylakoids , stacked in **grana** Flattened sacs whose membranes hold the photosystems and ATP synthase. Stacking gives a large surface for absorbing light. The space inside each thylakoid is tiny, so protons pumped in quickly build a steep gradient.

Starch grain A store of the sugar made by photosynthesis.

Ribosomes (70S) and a loop of **DNA** Like a mitochondrion, the chloroplast makes some of its own proteins.

WATCH OUT

The light-dependent reactions happen on the thylakoid membranes, not in the stroma.

PREDICT

Chloroplasts of plants grown in dim shade have more thylakoids in each granum than those grown in full sun. Why might this help?

(A) More thylakoids hold more Rubisco, so the Calvin cycle runs faster in the shade

(B) More thylakoids reflect more light back, so less light is wasted passing through

(C) More thylakoid membrane holds more photosystems, catching more of the little light there is

Decide before you look. Answer on page 25.

06 Two membranes, many *doors*

B2.2.6 HL FUNCTIONAL BENEFITS OF THE DOUBLE MEMBRANE OF THE NUCLEUS

The nucleus is wrapped in a **nuclear envelope** of two membranes. The outer one runs on into the rough ER. The double barrier keeps the genes apart from the busy cytoplasm, but the cell must still pass things through it: mRNA and ribosome subunits go out, while the enzymes for copying DNA and making mRNA come in. So the envelope is crossed by thousands of **nuclear pores**, protein channels that control what passes.

When the cell divides by mitosis or meiosis, the chromosomes must be shared out by a spindle that forms in the cytoplasm. So the envelope breaks down into small vesicles, the spindle reaches the chromosomes, and afterwards the vesicles fuse again into a new envelope around each set.

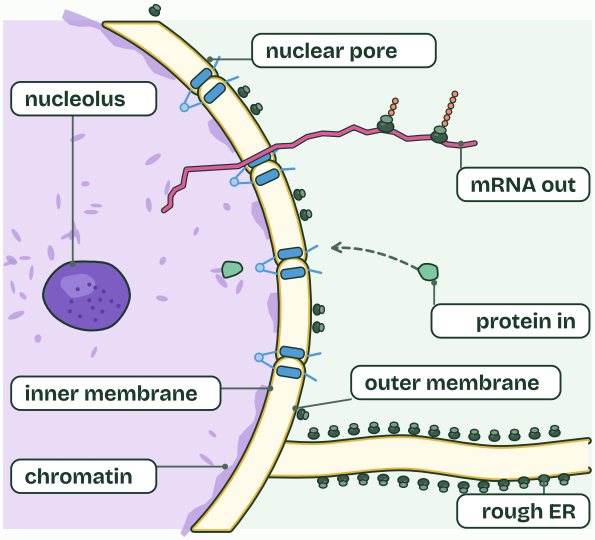
KEY POINTS

- Two membranes keep the genes in a compartment of their own.
- Pores let mRNA out and proteins in, under control.
- The envelope breaks into vesicles in division, and re-forms after.

KEY TERMS

nuclear envelope
The double membrane around the nucleus of a eukaryote cell, crossed by nuclear pores.

nuclear pores
Channels through the nuclear envelope, made of proteins, that control what passes between the nucleus and the cytoplasm.

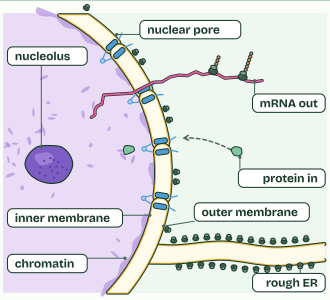


A double membrane, crossed by pores.
mRNA leaves through the pores, and proteins the nucleus needs, such as DNA polymerase, come in.

SWITCH IT

2 SETTINGS

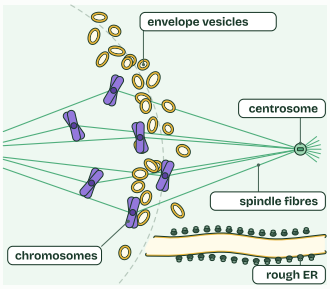
1



A double membrane, crossed by pores.
mRNA leaves through the pores, and proteins the nucleus needs, such as DNA polymerase, come in.

Between divisions

2



Dividing: the envelope breaks into vesicles,
so spindle fibres can reach the chromosomes.
Later the vesicles fuse to form two nuclei.

Dividing

WATCH OUT

Nuclear pores are not just holes. Each is a large complex of proteins that lets some molecules through and keeps others out.

PREDICT

Why does the nuclear envelope break down when a cell divides?

(A) So that the cell can make a fresh nucleus from scratch for each new cell, using new membrane

(B) So that the spindle fibres in the cytoplasm can reach the chromosomes and move them

(C) So that the DNA can be copied, which only happens when it is loose in the cytoplasm

Decide before you look. Answer on page 25.

B2.2.7 HL STRUCTURE AND FUNCTION OF FREE RIBOSOMES AND OF THE ROUGH ENDOPLASMIC RETICULUM

07 Made here, sent *there*

A ribosome has two subunits, a small and a large, each built of RNA and protein. Eukaryote ribosomes are 80S. All of them start translating in the cytoplasm, but where they finish depends on the protein. **Free ribosomes** stay in the cytosol and release their proteins there: proteins for use inside the cell, such as the enzymes of glycolysis.

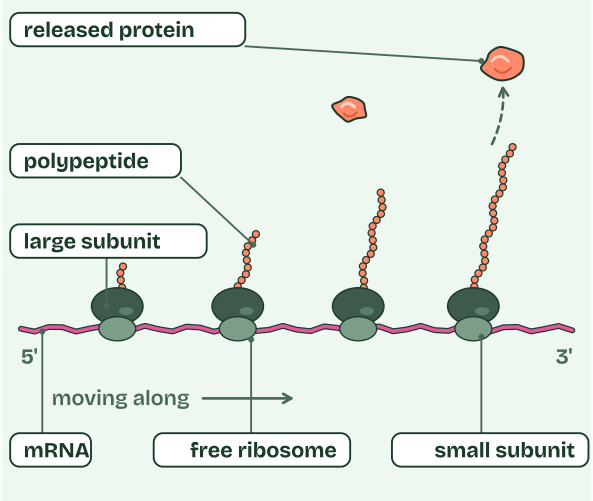
If the first part of a new protein is a signal sequence, the ribosome is taken to the **rough endoplasmic reticulum** and binds to its membrane. The protein is threaded into the ER's lumen as it is made. From there it can be sent out of the cell, put in a membrane or packed into a lysosome. Cells that secrete a lot, such as those making digestive enzymes, are full of rough ER.

KEY POINTS

- Free ribosomes: proteins kept in the cytosol.
- Bound ribosomes on rough ER: proteins for secretion, membranes and lysosomes.
- A signal sequence on the protein decides which.

KEY TERMS

rough endoplasmic reticulum
A network of flattened membrane sacs with ribosomes attached to the outer surface, which makes proteins for secretion, for membranes and for lysosomes.

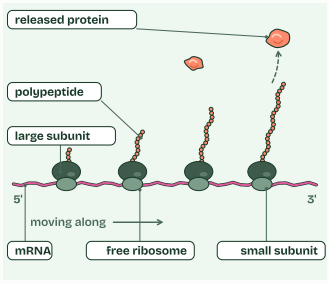


Free ribosomes: proteins for the cytosol.
Each releases its protein into the cytosol, for use in the cell, such as enzymes of glycolysis.

SWITCH IT

2 SETTINGS

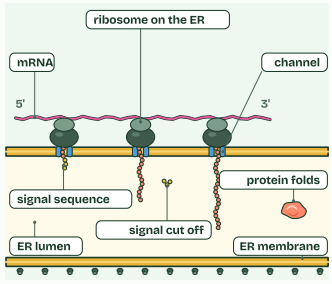
1



Free ribosomes: proteins for the cytosol.
Each releases its protein into the cytosol, for use in the cell, such as enzymes of glycolysis.

Free

2



Bound: proteins threaded into the ER lumen.
A signal sequence takes the ribosome to the ER. Made for export, for membranes or for lysosomes.

On the rough ER

WATCH OUT

Free and bound ribosomes are the same kind of ribosome. A ribosome binds to the ER only while it is making a protein with the signal.

PREDICT

A cell from the pancreas makes large amounts of a digestive enzyme for export. Which would you expect in its cytoplasm?

(A) Many free ribosomes and little ER, as the enzyme is made faster without a membrane

(B) Much rough ER, as proteins for secretion are made by ribosomes bound to it

(C) Many lysosomes, as the enzyme is stored in them until the cell releases it

Decide before you look. Answer on page 25.

08 Finish, label, *ship*

B2.2.8 HL STRUCTURE AND FUNCTION OF THE GOLGI APPARATUS

The **Golgi apparatus** is a stack of flattened, curved membrane sacs, the **cisternae**, with no ribosomes. Vesicles from the rough ER arrive at one face and fuse with it. As proteins move through the stack they are processed: sugars are added to make glycoproteins, and some are trimmed or folded further. At the far face they are sorted and leave in vesicles.

A **secretory vesicle** carries its protein to the plasma membrane and fuses with it, releasing the protein outside: **exocytosis**. The film follows one protein all the way, from its gene to the outside of the cell.

KEY POINTS

- Golgi: stacked cisternae, no ribosomes.
- Proteins from the rough ER arrive in vesicles, are modified, sorted and sent on.
- Secretory vesicles release proteins by exocytosis.

KEY TERMS

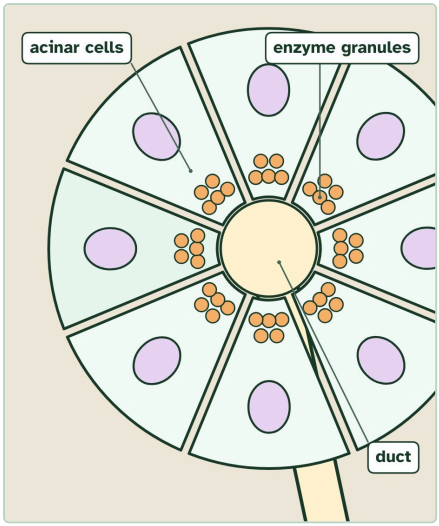
Golgi apparatus
A stack of flattened, curved membrane sacs that modifies proteins from the rough ER and packs them into vesicles.

cisternae
The flattened membrane sacs that make up the Golgi apparatus.

exocytosis
Release of substances from a cell when a vesicle fuses with the plasma membrane.

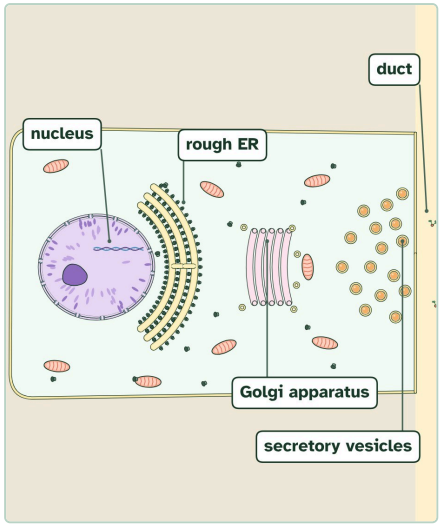
ANIMATION · FROM GENE TO OUTSIDE
13 MOMENTS

1 A PANCREAS ACINUS



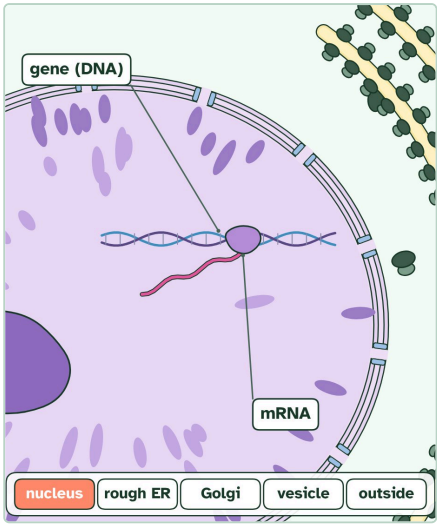
A pancreas is full of clusters of **acinar cells** round a duct. Each makes digestive enzymes and secretes them into the duct.

2 ONE ACINAR CELL



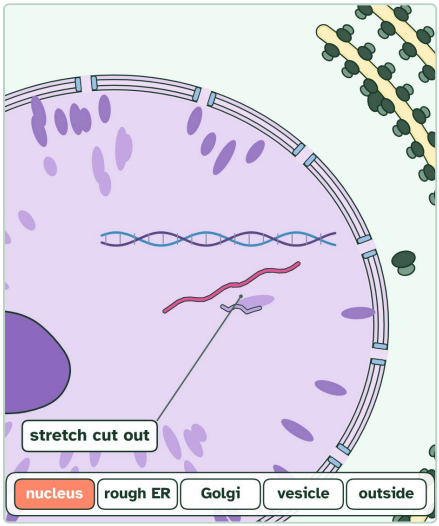
Inside one cell: the **nucleus**, sheets of **rough ER**, the **Golgi apparatus** and vesicles of enzyme waiting at the tip.

3 TRANSCRIPTION



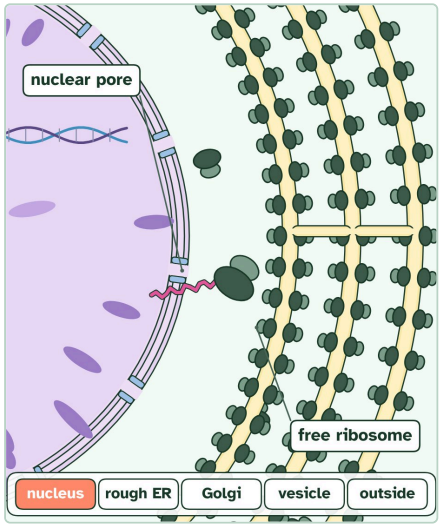
In the nucleus the gene for the enzyme is **transcribed**: an mRNA copy is made.

4 MRNA MODIFIED



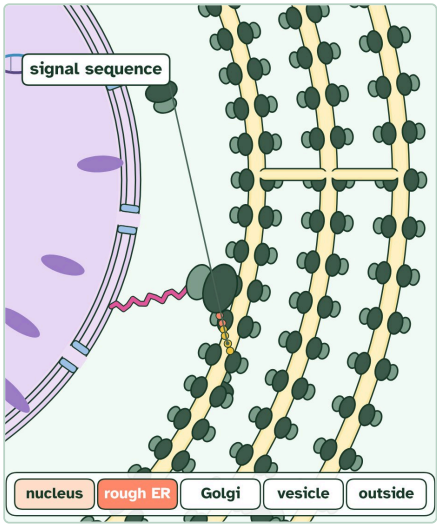
Still inside the nucleus, the mRNA is **modified**: stretches are cut out. No ribosome can reach it until this is done.

5 OUT THROUGH A PORE



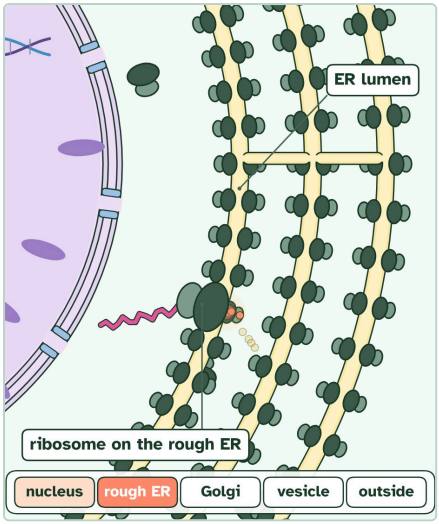
The finished mRNA leaves through a **nuclear pore**, and a free **ribosome** binds it in the cytoplasm.

6 TO THE ROUGH ER



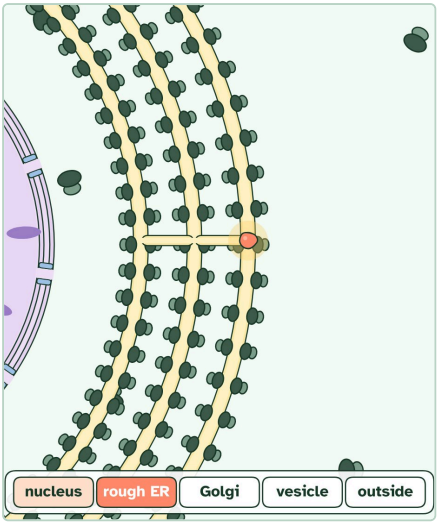
The first part of the new protein is a **signal sequence**. It leads the ribosome to the **rough ER**, where it binds.

7 INTO THE LUMEN



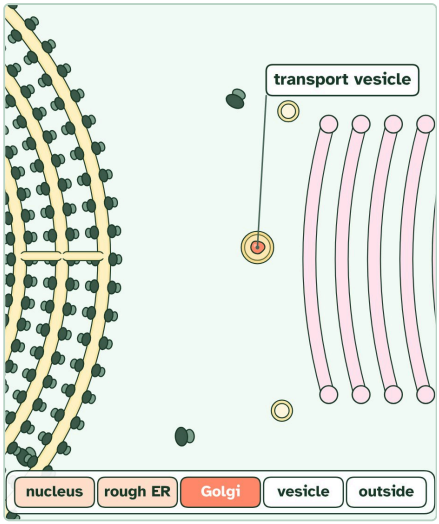
The growing chain is threaded through the membrane into the ER's **lumen**, where the signal is cut off and the protein folds.

8 TRANSPORT VESICLE



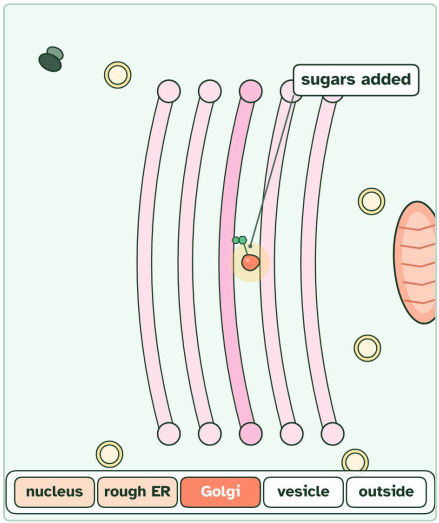
The protein moves through the lumen, and a piece of ER membrane buds off round it: a **transport vesicle**.

9 TO THE GOLGI



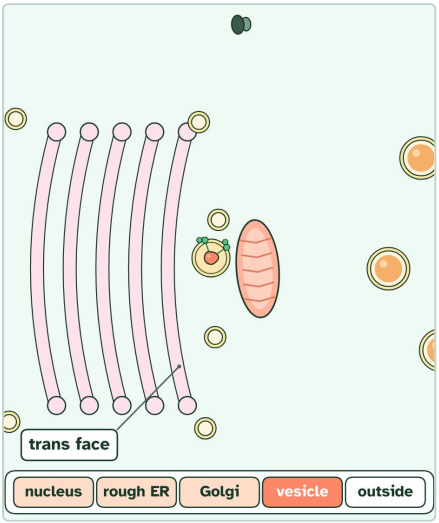
The vesicle crosses to the near face of the **Golgi apparatus** and fuses with it.

10 SUGARS ADDED



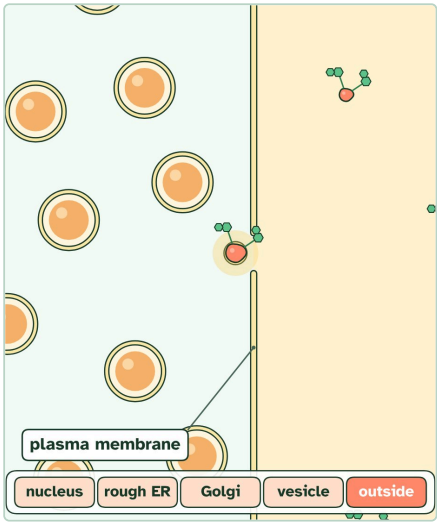
Cisterna by cisterna the protein is **modified**: here, chains of sugar are added.

11 SECRETORY VESICLE



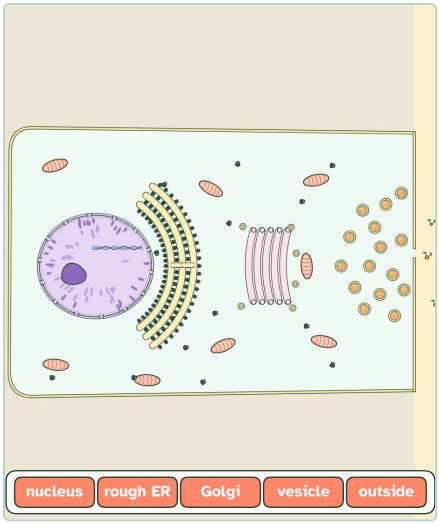
At the far face it buds off in a **secretory vesicle**, one of many waiting near the tip of the cell.

12 EXOCYTOSIS



The vesicle reaches the **plasma membrane** and fuses with it, releasing the enzyme into the duct: **exocytosis**.

13 THE WHOLE ROUTE



Nucleus, rough ER, Golgi, vesicle, out: every protein for secretion takes this route. Proteins kept in the cytosol are made by free ribosomes instead.

Watch it move, and change it as it runs: biologybybradford.com/guides/ib-biology-b2-2-organelles-and-compartmentalization#golgi

WATCH OUT

The Golgi does not make proteins. It receives them from the rough ER and changes them.

PREDICT

A drug stops vesicles leaving the rough ER. Where would a protein meant for secretion build up?

(A) In the Golgi apparatus, which it would reach but not leave

(B) In the lumen of the rough ER, where it was made and folded

(C) Outside the cell, as it would be secreted without being modified

Decide before you look. Answer on page 25.

09 Bubbles that *carry*

B2.2.9 HL STRUCTURE AND FUNCTION OF VESICLES IN CELLS

A **vesicle** is a small sac of membrane that carries substances inside the cell. Vesicles bud from one membrane and fuse with another, from the ER to the Golgi, from the Golgi to the plasma membrane or to lysosomes. Because a vesicle is made of membrane, its membrane joins the one it fuses with: exocytosis adds membrane to the cell surface.

Many vesicles are shaped by a protein called **clathrin**. In **endocytosis**, cargo molecules outside the cell bind receptors in the membrane. Clathrin gathers on the inner face of that patch and links into a cage, pulling the membrane into a pit. The pit deepens and pinches off as a coated vesicle. The coat then falls away, to be used again, and the vesicle carries its cargo on.

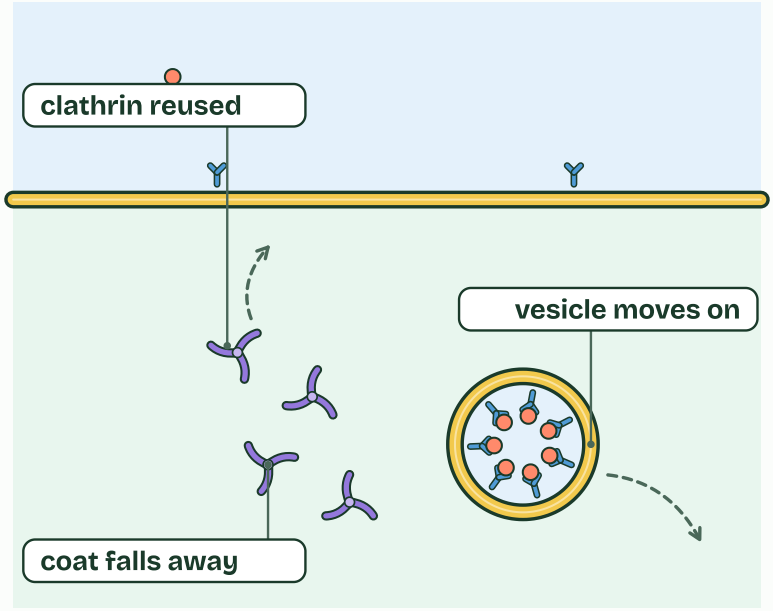
KEY POINTS

- Vesicles carry materials between membranes, and their membrane joins the target.
- Clathrin forms a coat that bends the membrane into a pit.
- The pit pinches off as a coated vesicle; the coat is recycled.

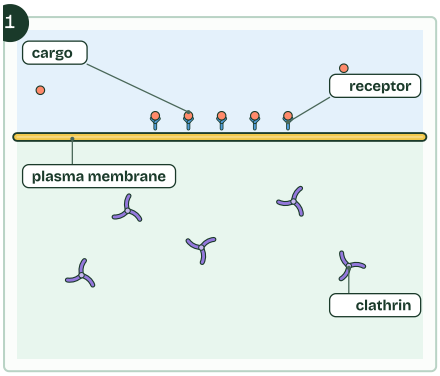
KEY TERMS

vesicle
A small sac of membrane that carries substances within a cell, or into or out of it.

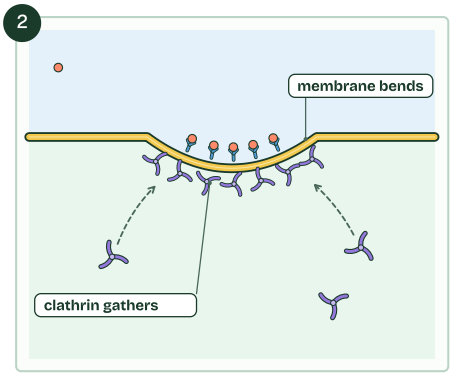
clathrin
A protein that assembles into a basket-like coat on the cytoplasmic side of a membrane, bending it into a pit that pinches off as a coated vesicle.



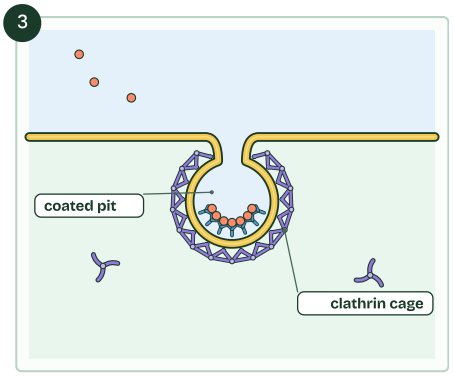
STEP BY STEP
5 STEPS



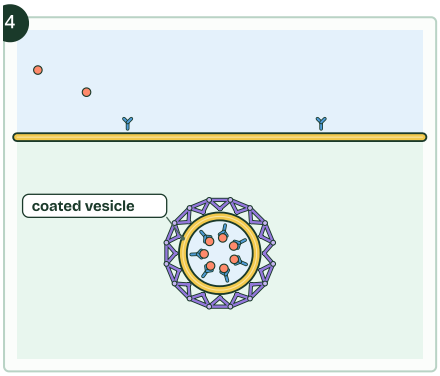
Cargo molecules outside the cell bind to **receptors** in the membrane.



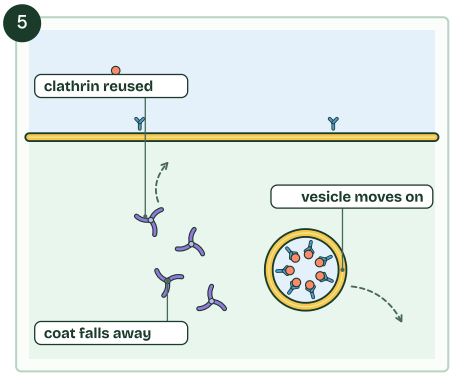
Clathrin gathers on the inner face and begins to bend the membrane.



The clathrin cage deepens it into a **coated pit**.



The pit pinches off: a **coated vesicle** with its cargo inside.



The **coat falls away** to be used again, and the vesicle moves on.

WATCH OUT

Clathrin is not in the membrane. It coats the cytoplasmic face from outside the bilayer, and comes off once the vesicle has formed.

PREDICT

A cell cannot make clathrin. What would it have trouble doing?

(A) Letting oxygen and carbon dioxide diffuse across its plasma membrane in either direction

(B) Taking in particular molecules from outside by forming vesicles at its surface

(C) Making new phospholipids for the membranes of its organelles and its surface

Decide before you look. Answer on page 26.

Key terms

Every term this guide defines, A to Z, with the chapter it is in. Cover the right-hand side and test yourself.

cell fractionation 01
Breaking cells open and separating their parts by spinning them in a centrifuge at increasing speeds, so that larger, denser parts settle first.

chloroplast 05
The organelle in plant and algal cells where photosynthesis takes place.

cisternae 08
The flattened membrane sacs that make up the Golgi apparatus.

clathrin 09
A protein that assembles into a basket-like coat on the cytoplasmic side of a membrane, bending it into a pit that pinches off as a coated vesicle.

cristae 04
The folds of the inner membrane of a mitochondrion, which give a large surface for electron transport chains and ATP synthase.

exocytosis 08
Release of substances from a cell when a vesicle fuses with the plasma membrane.

Golgi apparatus 08
A stack of flattened, curved membrane sacs that modifies proteins from the rough ER and packs them into vesicles.

grana 05
Stacks of thylakoids in a chloroplast.

intermembrane space 04
The narrow space between the outer and inner membranes of a mitochondrion, into which protons are pumped during respiration.

introns 02
Sections of a gene and of its first mRNA copy that do not code for the protein and are cut out before the mRNA is translated.

lysosomes 03
A small organelle bounded by one membrane, containing digestive enzymes that work best at an acid pH.

matrix 04
The fluid inside the inner membrane of a mitochondrion, holding the enzymes of the link reaction and the Krebs cycle.

mitochondria 04
The organelle where the later stages of aerobic respiration take place, producing most of a eukaryote cell's ATP.

nuclear envelope 06
The double membrane around the nucleus of a eukaryote cell, crossed by nuclear pores.

nuclear pores 06
Channels through the nuclear envelope, made of proteins, that control what passes between the nucleus and the cytoplasm.

organelle 01
A discrete structure within a cell, adapted to carry out a particular function.

phagocytic vacuole 03
A vacuole formed when a cell engulfs a large particle, such as a bacterium, by phagocytosis.

rough endoplasmic reticulum 07
A network of flattened membrane sacs with ribosomes attached to the outer surface, which makes proteins for secretion, for membranes and for lysosomes.

stroma 05
The fluid inside the inner membrane of a chloroplast, holding the enzymes of the Calvin cycle.

thylakoids 05
Flattened membrane sacs inside a chloroplast, whose membranes hold the photosystems and ATP synthase.

vesicle 09

A small sac of membrane that carries substances within a cell, or into or out of it.

Check yourself

The check for this guide is online: a fresh paper of past-paper style questions from the exam bank on B2.2 each time, marked as you go, and saved to your Exam practice progress when you are signed in. Scan the code, or type the link.

biologybybradford.com/exam-maker/sit?topics=B2.2&level=HL&paper=quiz&marks=15&src=ep

Answers

PREDICTIONS IN THE CHAPTERS

01 Why is the buffer used in fractionation kept ice cold and at the same concentration as the cytoplasm?

B **Cold slows enzymes that would digest the organelles, and the same concentration stops osmosis bursting them**

Once cells are broken, enzymes from lysosomes are released and would start to digest everything; cold slows them down. In a solution of the same concentration (isotonic), water does not rush into the organelles and burst them.

02 What could go wrong if ribosomes reached a eukaryote's mRNA before it left the nucleus?

B **The ribosomes would translate the introns too, making a faulty protein**

The first mRNA copy still has its introns. Translated straight away, they would add wrong amino acids or stop the protein early. Keeping ribosomes out of the nucleus means only edited mRNA is read.

03 A lysosome leaks a little of its contents into the cytoplasm. Why does this do the cell little harm?

C **The enzymes work best at an acid pH and are much less active at the pH of the cytoplasm**

The enzymes are adapted to about pH 5, inside the lysosome. In the cytoplasm, at about pH 7, they work slowly, a second line of safety on top of the membrane.

04 Heart muscle cells have mitochondria with many more cristae than those of skin cells. Why?

B **More cristae give more membrane for ATP synthase, and heart muscle uses ATP very fast**

Heart muscle contracts all the time and needs a great deal of ATP. More cristae mean more inner membrane, so more electron transport chains and ATP synthase, and more ATP made per mitochondrion.

05 Chloroplasts of plants grown in dim shade have more thylakoids in each granum than those grown in full sun. Why might this help?

C **More thylakoid membrane holds more photosystems, catching more of the little light there is**

Light is what limits a plant in shade. More thylakoid membrane means more photosystems to absorb what light arrives. Rubisco is in the stroma, not the membranes.

06 Why does the nuclear envelope break down when a cell divides?

B **So that the spindle fibres in the cytoplasm can reach the chromosomes and move them**

The spindle forms in the cytoplasm and must attach to the chromosomes to pull them apart. The DNA was copied earlier, inside the nucleus. The envelope's pieces are kept as vesicles and used again.

07 A cell from the pancreas makes large amounts of a digestive enzyme for export. Which would you expect in its cytoplasm?

B **Much rough ER, as proteins for secretion are made by ribosomes bound to it**

A protein for export is made on ribosomes bound to the rough ER and goes on through the Golgi in vesicles. Secreting cells are packed with rough ER.

08 A drug stops vesicles leaving the rough ER. Where would a protein meant for secretion build up?

B **In the lumen of the rough ER, where it was made and folded**

The protein is threaded into the ER as it is made, and its only way on to the Golgi is in a vesicle. Block the vesicles and it piles up in the ER lumen.

09 A cell cannot make clathrin. What would it have trouble doing?

B **Taking in particular molecules from outside by forming vesicles at its surface**

Clathrin is what bends the membrane into a coated pit, so without it the cell cannot take in cargo by this route, such as the cholesterol carried in the blood. Gases cross by simple diffusion and need no vesicles.

How this was made. The course structure, the activities and the teaching choices come from my own classroom, my presentations and my years of teaching IB and AP Biology. I use Claude, an AI, to help write and build the interactive guides, lesson plans, slides and practice questions, and to draw the diagrams and code the interactives. I direct the work and review it against the IB and AP specifications before it goes live.

Written and drawn for Biology by Bradford, biologybybradford.com. Free to print and share with a class.