

[Home](#)
 Overview
 (/study/app/
 422-
 cid-
 755105/o)

[Table of
contents](#)

[Notebook](#)

[Glossary](#)

[B2. Form and function: Cells / B2.1 Membranes and membrane transport](#)

[Reading
assistance](#)

The big picture

[File](#) [O](#) [Q](#) [?](#)(<https://intercom.help/kognity>) [Bell](#) 

Index

- [The big picture](#)
- [Lipid bilayers](#)
- [Membrane proteins and their functions](#)
- [Facilitated diffusion and active transport in selective permeability of membranes](#)
- [Fluid mosaic model](#)
- [Membrane fluidity \(HL\)](#)
- [More about transport mechanisms \(HL\)](#)
- [CAMs and cell adhesion \(HL\)](#)
- [Summary and key terms](#)
- [Checklist](#)
- [Investigation](#)
- [Reflection](#)

Section

Student... (0/0)

[Feedback](#)

[Print](#)

(/study/app/bio/sid-422-cid-755105/book/the-big-picture-id-

43205/print/)

[Assign](#)

? Guiding question(s)

- How do molecules of lipid and protein assemble into biological membranes?
- What determines whether a substance can pass through a biological membrane?

Keep the guiding questions in mind as you learn the science in this subtopic. You will be ready to answer them at the end of this subtopic. The guiding questions require you to pull together your knowledge and skills from different sections, to see the bigger picture and to build your conceptual understanding.

One way of understanding properties of biological membranes is through soap bubbles. Think of big soap bubbles. A soap bubble is just a bubble of air enclosed by a thin film of soap detergent. If you look closely you would see that the film is flexible and fluid. The film acts as a barrier; it is a fragile, invisible, yet complex structure, separating the interior from the exterior.

In **Figure 1** you can see that the film is composed of a layer of water enclosed between two layers of soap molecules. The soap molecules have two ends. As these molecules form the film, they organise themselves so that their hydrophilic (water-loving) heads point towards the water and their hydrophobic (water-hating) tails point outward.

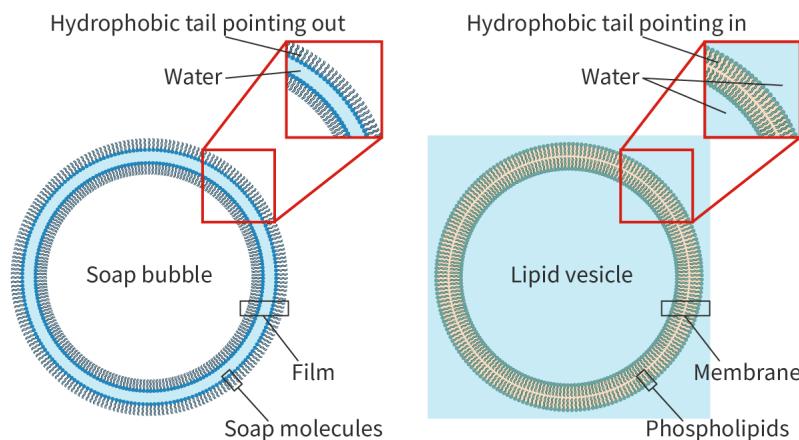


Figure 1. Bubbles and biological membranes.

[Student
view](#)



Overview
(/study/app/422-cid-755105/o)

This image is a diagram comparing the structures of a soap bubble and a lipid vesicle. On the left, a circular representation of a soap bubble is shown, labeled as 'Soap bubble'. The bubble consists of a thin film made of a layer of water enclosed between two layers of soap molecules. The soap molecules have hydrophilic heads pointing towards the water and hydrophobic tails pointing outward. A close-up shows the alignment of these molecules.

On the right, a circular representation of a lipid vesicle, labeled as 'Lipid vesicle', is displayed. Similar to the soap bubble, it has a water layer, but the structure is made of phospholipid molecules which form a membrane. The hydrophobic tails of the phospholipid molecules point inward. A close-up also shows the alignment of these molecules, highlighting the similarity in molecular behavior between soap films and biological membranes.

[Generated by AI]

Biological membranes in many ways are similar: they are fluid, flexible and dynamic. While the structure of a biological membrane is different from that of a soap film, the behaviour of the soap molecules and the phospholipid molecules (see [section B1.1.1-3 \(/study/app/bio/sid-422-cid-755105/book/chemical-bonding-and-polymerisation-id-44681/\)](#)) that make up the membranes are similar.

How do molecules of phospholipids assemble into biological membranes? What are phospholipids made of? Do all substances pass through these membranes with equal ease? Does the structure of a membrane play a role in the movement of substances across it?

Prior learning

Before you study this subtopic make sure that you understand the following:

- The physical and chemical properties of water (see [subtopic A1.1 \(/study/app/bio/sid-422-cid-755105/book/the-big-picture-id-43193/\)](#)).
- Structures, forms and functions of carbohydrates and lipids (see [subtopic B1.1 \(/study/app/bio/sid-422-cid-755105/book/big-picture-id-43530/\)](#)).
- Variation in structures and functions of proteins (see [subtopic B1.2 \(/study/app/bio/sid-422-cid-755105/book/big-picture-id-43531/\)](#)).

B2. Form and function: Cells / B2.1 Membranes and membrane transport

Lipid bilayers

[B2.1.1: Lipid bilayers in cell membranes](#) [B2.1.2: Lipid bilayers as barriers](#) [B2.1.3: Simple diffusion across membranes](#)

Section

Student... (0/0)

Feedback



Print [\(/study/app/bio/sid-422-cid-755105/book/lipid-bilayers-id-44634/print/\)](#)

Assign

Student view

Learning outcomes

By the end of this section you should be able to:

- Describe the formation of sheet-like bilayers in water by amphipathic lipids.
- Explain the reasons behind the selective permeability of the lipid bilayer.



Overview

(/study/app

422-

cid-

755105/o

- Discuss the movement of molecules by diffusion across the lipid bilayer.

On average, nearly 55–65% of the human body is made of water. Water molecules are polar in nature and capable of forming hydrogen bonds (see [section A1.1.1–3 \(/study/app/bio/sid-422-cid-755105/book/structure-of-water-id-43194/\)](#)). In other words, the two hydrogen atoms of water frequently break and form hydrogen bonds with the molecules around them. Polar molecules easily form hydrogen bonds with water thereby getting dissolved. These molecules are often called hydrophilic (see [section A1.1.4–5 \(/study/app/bio/sid-422-cid-755105/book/interactions-with-water-id-43195/\)](#)).

On the other hand, hydrophobic (see [section A1.1.4–5 \(/study/app/bio/sid-422-cid-755105/book/interactions-with-water-id-43195/\)](#)) non-polar molecules are unable to form hydrogen bonds. Yet the interactions of these molecules are fundamental to cell structure. How do hydrophobic molecules like lipids interact with water? How do these interactions become fundamental for membrane structure?

Overview of membrane structure

Membranes surround cells and organelles. These membranes act as barriers controlling the exchange of materials between the internal and external environment. The membranes are composed of:

- lipids (see [subtopic B1.1 \(/study/app/bio/sid-422-cid-755105/book/big-picture-id-43530/\)](#)) like phospholipids, glycolipids and sterols
- proteins (see [section B1.2.11–12 \(/study/app/bio/sid-422-cid-755105/book/quaternary-structure-of-proteins-and-form-id-44446/\)](#))
- small amounts of carbohydrates in the form of glycolipids and glycoproteins (see [section B2.1.9–10 \(/study/app/bio/sid-422-cid-755105/book/fluid-mosaic-model-id-44645/\)](#)).

These lipids and some of the proteins that compose the membrane are amphipathic molecules with both hydrophobic and hydrophilic regions. You can read about these molecules in [subtopics B1.1 \(/study/app/bio/sid-422-cid-755105/book/big-picture-id-43530/\)](#) and [B1.2 \(/study/app/bio/sid-422-cid-755105/book/big-picture-id-43531/\)](#).

Lipid bilayer

Lipids are essential components of membranes, and include three major classes of lipids – phospholipids, glycolipids (see [section B2.1.9–10 \(/study/app/bio/sid-422-cid-755105/book/fluid-mosaic-model-id-44645/\)](#)) and sterols like cholesterol ([section B2.1.11–13 \(/study/app/bio/sid-422-cid-755105/book/membrane-fluidity-hl-id-44646/\)](#)).

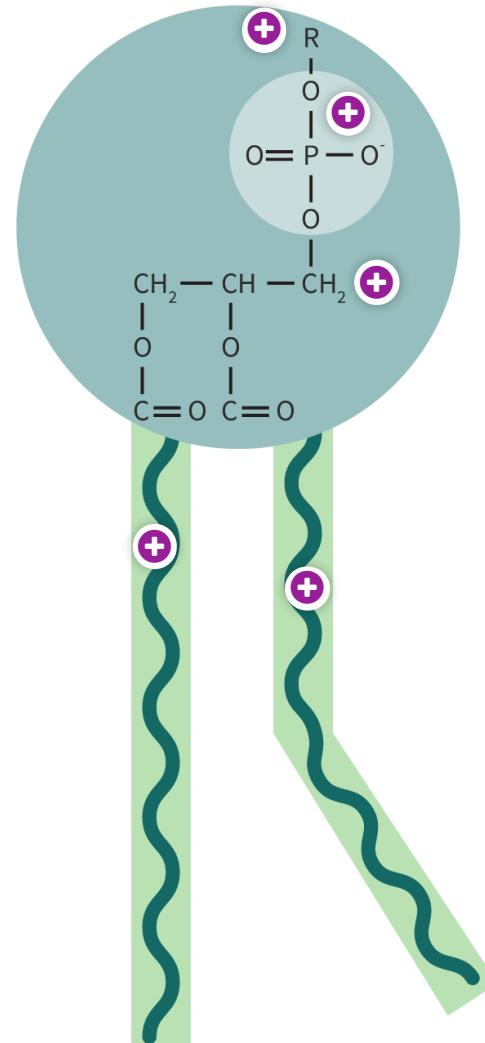
Membrane phospholipids (see [section B1.1.12–13 \(/study/app/bio/sid-422-cid-755105/book/phospholipid-bilayer-id-44683/\)](#)) are the most abundant and diverse lipids. Let us quickly review the structure of phospholipid molecules.

A phospholipid molecule comprises a backbone composed of mostly glycerol, a three-carbon alcohol. Attached to the backbone are:

- a negatively charged phosphate molecule linked to molecules like choline or serine forming a polar, hydrophilic, ‘head’ group. The polar head easily forms hydrogen bonds with water.
- two non-polar fatty acid chains forming the hydrophobic ‘tails’. The fatty acids could be saturated or unsaturated. Unsaturated fatty acids result in kinks in the tail.



Click on the hotspots in **Interactive 1** to learn more about the features of a phospholipid molecule.



Interactive 1. A Schematic Representation of a Phospholipid Molecule.

More information for interactive 1

The interactive image represents a phospholipid molecule, a key component of cell membranes. There are five different hotspots in the interactive, at different parts of the phospholipid molecule. Each hotspot is represented by a plus sign and clicking on these hotspots reveals more information about different parts of the phospholipid molecule. The hotspots are named hotspot 1, hotspot 2, hotspot 3, hotspot 4, and hotspot 5.

The phospholipid in the image is composed of two main parts: a hydrophilic (water-attracting) head and two hydrophobic (water-repelling) tails.

Read below for information regarding each part:

Hydrophilic Head:

The hydrophilic head in the image is represented by a large greenish-blue circle. Inside this circular head is a detailed chemical structure consisting of: A phosphate group in the center. It includes: A phosphorus atom (P) bonded to four oxygen atoms (O), one of which has a negative charge (O^-). One oxygen is double bonded to the phosphorus ($O = P$), and one oxygen connects to a variable group denoted by "R". The hotspot 1 is located near this "R" group, and clicking on this hotspot reveals the text "Charged or polar functional group". Hotspot 2 is located near the phosphate group in the center, and clicking on it reveals the text "Negatively charged phosphate group".

Below the phosphate group, connected to it, is a glycerol backbone represented by three carbon atoms ($CH_2-CH-CH_2$). Two of these carbon atoms are bonded to fatty acid chains via ester bonds ($-COO-$). Hotspot 3 is located near this glycerol backbone and clicking on this hotspot reveals the text "3 C backbone of glycerol".

Hydrophobic tails:

The image shows two hydrophobic tails extending from the bottom of the hydrophilic head, each representing a fatty acid chain. Each tail is depicted as a vertical, light green strip with a dark green squiggly line inside it, symbolizing the hydrocarbon chains of the fatty acids.

The tail on the left is straight indicating membrane rigidity. Hotspot 4 is located on this tail, and clicking on this hotspot reveals the text "Fatty acid tail-1 (saturated fatty acid)".

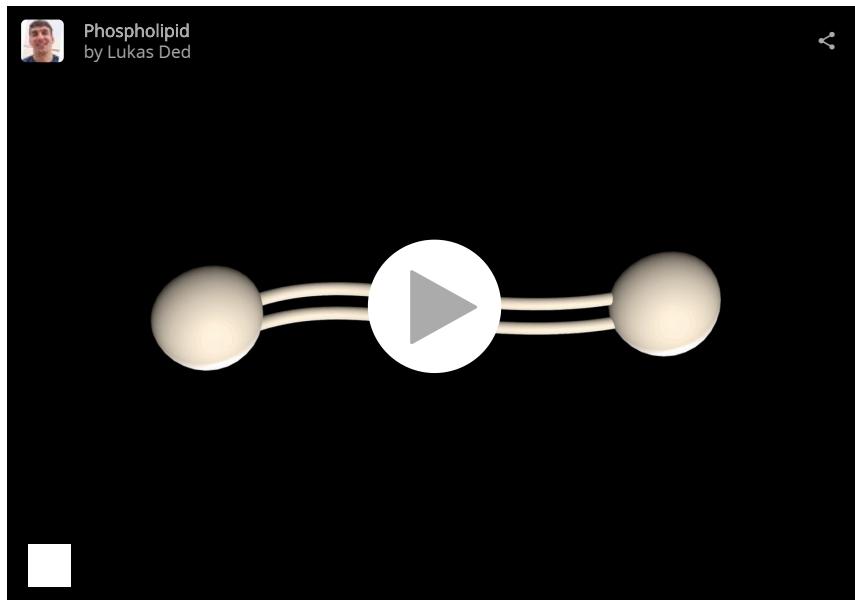


Overview
(/study/app/
422-
cid-
755105/o

The tail on the right is bent and twisted, indicating that it contains kinks due to the presence of one or more double bonds. Hotspot 5 is located on this tail and clicking on it reveals the text "Fatty acid tail-2 (unsaturated fatty acid)".

The interactive image helps viewers understand the basic structure of a phospholipid molecule and helps identify the hydrophilic and hydrophobic regions of the molecule. This image simplifies the complex chemistry of phospholipids for educational purposes, highlighting both the structural elements and their chemical properties with visual cues like color, shape, and symbols.

The amphipathic nature of phospholipids is responsible for the unique structure of biological membranes. In an aqueous environment, phospholipid molecules spontaneously organise themselves in a way that their hydrophobic tails are shielded from water. This means that the hydrophobic tails point inward and away from the aqueous environment, whereas the hydrophilic heads point outward. This results in the formation of two layers or lipid bilayers (**Interactive 2**).



Interactive 2. Three-dimensional Models of a Phospholipid Molecule.

More information for interactive 2

A 3D interactive model of phospholipids is given. Each distinct unit consists of three parts: a hydrophilic head represented by the spherical structure and two hydrophobic tails represented by the wavy lines connecting one phospholipid molecule to another.

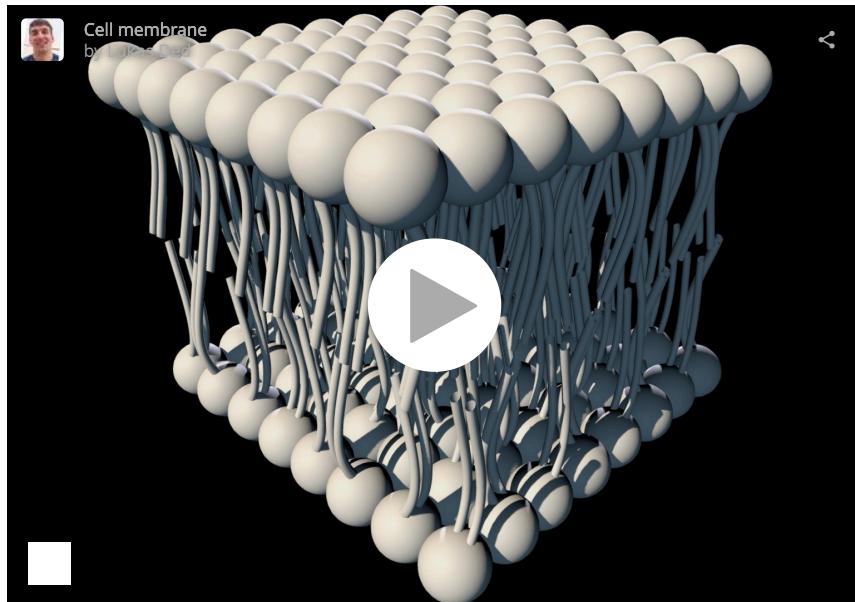
The interactive nature of this model allows the user to rotate and explore the phospholipids from different angles, providing a better understanding of their three-dimensional structure.

This model effectively conveys the formation of lipid bilayers.



Student
view

 Overview
(/study/app/
422-
cid-
755105/o)



Interactive 3. Three-dimensional Models of the Lipid Bilayer.

 More information for interactive 3

An interactive 3D model illustrates the structure of a phospholipid bilayer. The model consists of spheres that represent the hydrophilic heads of phospholipids, which are attracted to water, and long, thin, tail-like structures that represent the hydrophobic tails of the phospholipids, which repel water. These tails are sandwiched between the two layers of heads.

The interactive nature of this model allows the user to rotate and explore the bilayer from different angles, providing a clear understanding of its three-dimensional arrangement.

This model effectively demonstrates how the unique properties of phospholipids lead to the formation of a lipid bilayer. The hydrophilic heads interact with the aqueous environment (both extra and intra cellular), while the hydrophobic tails are pointed inward, away from the aqueous environment. The spontaneous arrangement of the phospholipids in an aqueous environment leads to the formation of a lipid bilayer.

In **Interactive 2**, you will notice that the phospholipid molecules are arranged in two layers with the tails of one layer facing the tails of the other layer. The hydrophilic heads of the inner layer face the internal aqueous environment of the cell or cell organelle, and the heads of the outer layer face the external aqueous environment.

The lipid bilayer also includes molecules of cholesterol (see [section B2.1.11–13 \(/study/app/bio/sid-422-cid-755105/book/membrane-fluidity-hl-id-44646/\)](#) in animal cells). These molecules are amphipathic in nature.

Lipid bilayers as barriers

Biological membranes separate the internal environment of the cell or organelle from the external environment. Lipid bilayers occur in almost all biological membranes and regulate the movement of substances.

The hydrocarbon tails of both layers extend inward to form a continuous hydrophobic interior; this has an important role in determining the permeability of the membrane (**Figure 1**).

- As the interior of the bilayer is hydrophobic, non-polar, lipid-soluble molecules like steroids can easily pass through the lipid bilayer.
- On the other hand, for the same reason, ions like Na^+ cannot pass through the membrane.
- Uncharged polar molecules like glucose are hydrophilic in nature. These molecules are ‘repelled’ by the cell membrane, i.e. the membrane is mostly impermeable to them.

 Student view



- Small, uncharged molecules can readily pass through the lipid bilayer. Thus, polar molecules like water and ethanol or non-polar molecules like oxygen and carbon dioxide can easily enter or leave cells.

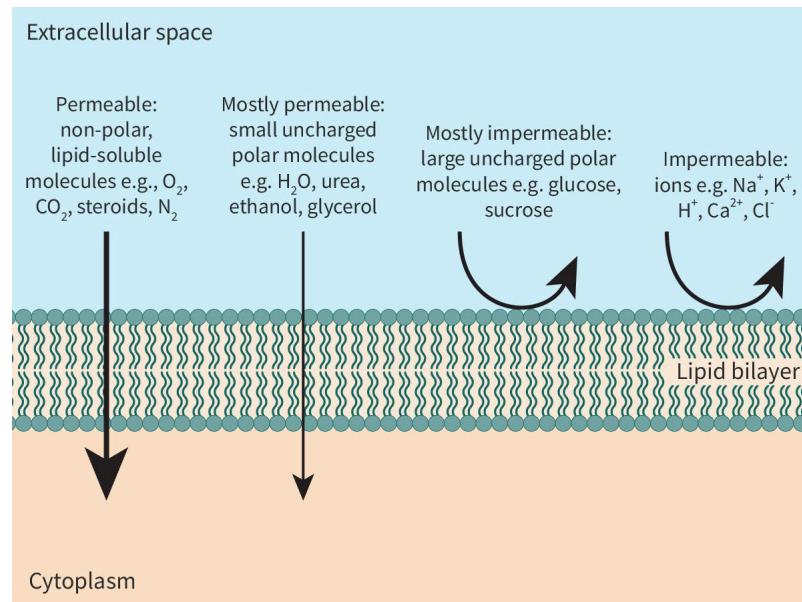


Figure 1. Permeability of the lipid bilayer.

More information for figure 1

The image is a diagram illustrating the permeability of the lipid bilayer to different types of molecules. It is divided into sections corresponding to the extracellular space at the top and the cytoplasm at the bottom. The lipid bilayer itself is depicted as a double-layered structure composed of a sequence of circular and wavy lines.

Four categories of permeability are shown:

- "Permeable: non-polar, lipid-soluble molecules e.g., O₂, CO₂, steroids, N₂" - Arrows indicate that these molecules easily pass through the lipid bilayer.
- "Mostly permeable: small uncharged polar molecules e.g., H₂O, urea, ethanol, glycerol" - These molecules pass through readily but with less permeability than non-polar molecules.
- "Mostly impermeable: large uncharged polar molecules e.g., glucose, sucrose" - These molecules are less likely to pass through the bilayer, indicated by arrows pointing back towards the extracellular space.
- "Impermeable: ions e.g., Na⁺, K⁺, H⁺, Ca²⁺, Cl⁻" - These ions cannot pass through the lipid bilayer, as shown by arrows pointing away from it.

The diagram effectively demonstrates how the lipid bilayer selectively allows different molecules to pass based on their characteristics.

[Generated by AI]

🔗 Making connections

Just like phospholipids, fatty acids and glycerols are key components of fats (see [section B1.1.8—11 \(/study/app/bio/sid-422-cid-755105/book/properties-and-functions-of-lipids-id-44588/\)](#) too. Yet, chemically fatty acids differ from phospholipids.



Home
Overview
(/study/app/
422-
cid-
755105/o

The permeability of biological membranes to molecules depends on the size of the molecules and their hydrophilic/hydrophobic nature. As most of the constituents (parts) of the cell are polar or charged, biological membranes form barriers, preventing the unneeded entry or exit of these molecules from the cell.

The direction of the arrows given in **Interactive 3** indicates the relative permeability of the membrane to various molecules. Drag and drop the molecules to indicate their permeability.

The diagram illustrates a cell membrane as a lipid bilayer separating the "Extracellular space" (top, light blue) from the "Cytoplasm" (bottom, light orange). Four vertical arrows point downwards through the bilayer, representing different substances. The first arrow is labeled "Permeable" and has a straight path. The second arrow is labeled "Mostly permeable" and also has a relatively straight path. The third arrow is labeled "Mostly impermeable" and curves upwards and away from the bilayer. The fourth arrow is labeled "Impermeable" and is completely deflected back into the extracellular space. Labels above the arrows indicate their permeability: "Permeable", "Mostly permeable", "Mostly impermeable", and "Impermeable".

Cl⁻
K⁺
Sucrose
Oestradiol
Oxygen
Water

Check

Interactive 3. Permeable or Not?

More information for interactive 3

This is an interactive drag-and-drop activity where the image depicts a cell membrane, specifically the lipid bilayer, which is shown as two parallel rows of oval shapes with wavy lines extending from them. The top row faces upwards towards a light blue area labeled "Extracellular space", and the bottom row faces downwards towards a light brown area representing the inside of the cell labelled as "Cytoplasm". At the center of these, there is a layer of lipid cells represented by two layers of molecules arranged tail-to-tail.

Above the lipid bilayer, in the extracellular space, there are four scenarios illustrating the permeability of different substances.

From left to right:

First, labeled "Permeable", a straight black arrow points directly downwards through both layers of the lipid bilayer, indicating that this substance can easily pass through the membrane.

Second, labeled "Mostly permeable", a slightly shorter straight black arrow also points directly downwards through both layers of the lipid bilayer, suggesting that this substance can pass through, but perhaps with some resistance or not as readily as the "permeable" substance.

Third, Labeled "Mostly impermeable", a curved black arrow starts pointing downwards towards the top layer of the lipid bilayer, curves to follow the surface of the bilayer, and then curves upwards and away, indicating that this substance has difficulty crossing the membrane and is mostly deflected back into the extracellular space.

Fourth, labeled "Impermeable", a curved black arrow starts pointing downwards towards the top layer of the lipid bilayer, curves to follow the surface, and then curves sharply upwards and away, indicating that this substance cannot pass through the membrane and is completely deflected back into the extracellular space.

Student view

The diagram illustrates how the lipid bilayer acts as a selective barrier, allowing some substances to pass through easily while hindering or preventing the passage of others.

There are six options given at the bottom, Cl^- , K^+ , Sucrose, Oestradiol, Oxygen and Water. There is more than one option for two gaps.

Read below for the solution:

First box- Oestradiol and Oxygen are permeable.

Second box- Water is mostly permeable.

Third box- Sucrose is mostly impermeable.

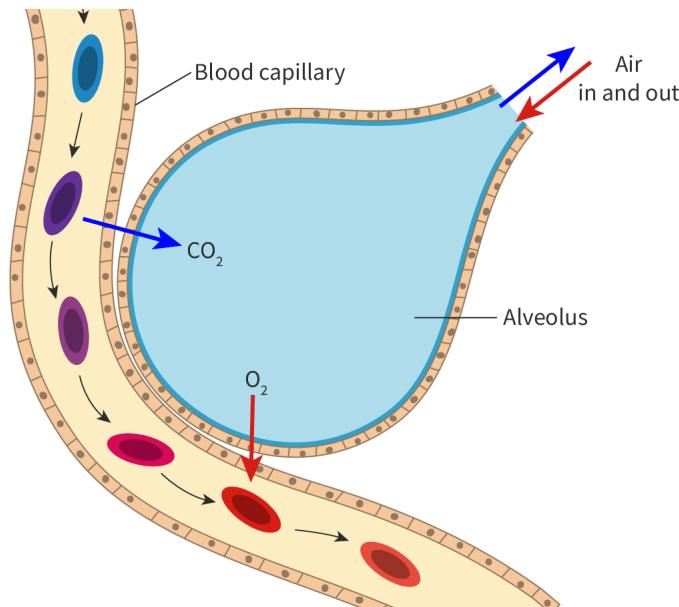
Fourth box- Cl^- and K^+ are impermeable.

Simple diffusion of molecules

One of the easiest ways for molecules to move across the membrane is by simple diffusion. Simple diffusion is the movement of molecules of a substance down a concentration gradient, i.e. from a region of where its concentration is higher to a region where its concentration is lower. Diffusion is a spontaneous process and the movement of molecules eventually results in equilibrium, i.e. in equal concentration of the molecules in both the regions. It is also a passive process, i.e. it does not involve the expenditure of energy by cells.

One example of simple diffusion is the movement of non-polar molecules like oxygen and carbon dioxide, which plays an important role in gas exchange (see [subtopic B3.1 \(/study/app/bio/sid-422-cid-755105/book/big-picture-id-43534/\)](#)). The erythrocytes or red blood cells (RBCs) transport oxygen from the lungs to the cells of the body. The oxygen diffuses from the oxygen-rich air in the alveoli down the concentration gradient to blood (erythrocytes) in the capillaries surrounding the alveoli. This oxygen is carried to tissues. In tissues, the oxygen diffuses from erythrocytes where oxygen concentration is higher to metabolically active cells where oxygen concentration is lower.

At the same time, in tissues, carbon dioxide diffuses from the cells where its concentration is higher to blood where its concentration is lower. The carbon dioxide is then carried to the lungs. In the lungs, the carbon dioxide diffuses from the blood to the alveoli down the concentration gradient. **Figure 2** illustrates the process. To keep this simple, the reactions that happen within erythrocytes have not been included here.



More information

Home
Overview
(/study/app/
422-
cid-
755105/o

The diagram illustrates the process of gas exchange in the alveolus, the small air sac in the lungs. The image features a cross-section of a blood capillary and an alveolus. The blood capillary is shown with a circular cross-section running vertically alongside an oval-shaped alveolus. Arrows demonstrate the directional flow of gases: CO₂ moves from the blood capillary into the alveolus, and O₂ moves from the alveolus into the blood capillary. The blood capillary has labeled cells, with an arrow indicating the movement of CO₂ towards the alveolus. Conversely, O₂ moves in the opposite direction. The alveolus is colored blue, highlighting the exchange surface. Labels identify the blood capillary and alveolus, with additional text noting 'Air in and out' to signify the external air moving through the alveolus.

[Generated by AI]

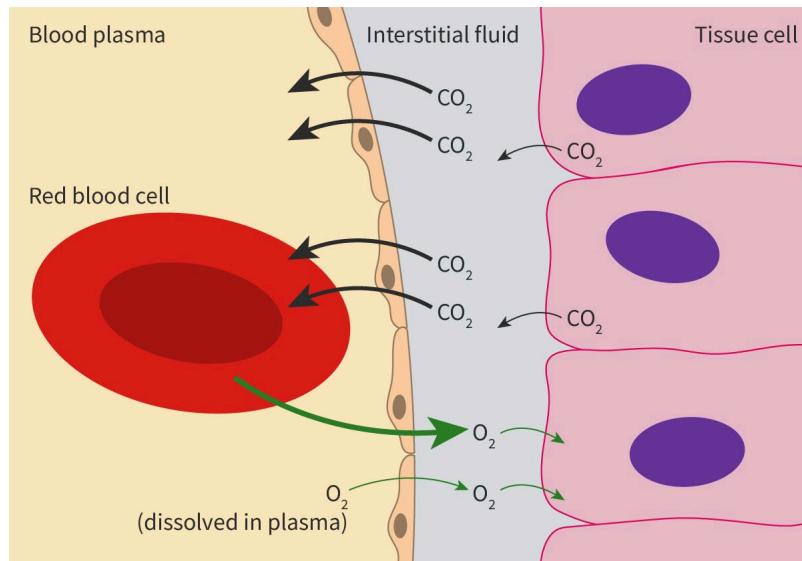


Figure 2. Diffusion of gases down the concentration gradient.

More information for figure 2

The image is a diagram illustrating the diffusion of gases across a membrane, specifically between blood plasma and tissue cells. On the left, there is a representation of a red blood cell within the blood plasma, labeled in red. The central region shows a thin membrane depicting interstitial fluid. On the right side are tissue cells, shaded in purple, illustrating the diffusion process.

Arrows are used to indicate the movement of carbon dioxide (CO₂) and oxygen (O₂). Black arrows show CO₂ moving from tissue cells through the interstitial fluid into the red blood cells. Arrows also depict CO₂ moving in the opposite direction, from the tissue cells into the blood plasma.

Green arrows show the diffusion of oxygen, (labeled as O₂ dissolved in plasma) from the blood plasma through the interstitial fluid and into the tissue cells. The diagram depicts the gases moving passively down their concentration gradient, illustrating the physiological process of gas exchange.

[Generated by AI]

Clearly both oxygen and carbon dioxide diffuse passively and easily through lipid bilayers down their concentration gradient.

However, the hydrophobic nature of the lipid bilayer restricts simple diffusion of most molecules. Only non-polar molecules like oxygen or carbon dioxide or very small polar molecules like water or alcohol, can diffuse across membranes.

Student view



Try this Think-Pair-Share activity to test your understanding of lipid bilayers.

Overview
(/study/app/
422-
cid-
755105/o)

Activity

- **IB learner profile attribute:** Inquirer
- **Approaches to learning:** Thinking skills — Applying key ideas and facts in new contexts
- **Time required to complete activity:** 20 minutes
- **Activity type:** Pair activity

Your task

Read the 'What if' questions.

Use Think-Pair-Share. Think on your own, discuss with your partner and share with the class.

Make sure that your 'thinking and discussion' are supported by sketches/diagrams.

1. What if polar groups are attached to the hydrophobic tails of phospholipid molecules? Would it affect the formation of the lipid bilayer and transport of molecules?
2. What if non-polar groups are attached to the phosphate groups of phospholipid molecules? Would it affect the formation of the lipid bilayer and transport of molecules?

5 section questions ▾

B2. Form and function: Cells / B2.1 Membranes and membrane transport

Membrane proteins and their functions

B2.1.4: Integral and peripheral proteins in membranes B2.1.5: Osmosis

Section

Student... (0/0)

Feedback

Print

(/study/app/bio/sid-422-cid-755105/book/membrane-proteins-and-their-functions-id-44638/print/)

Assign



Learning outcomes

By the end of this section you should be able to:

- Identify integral and peripheral proteins.
- Discuss the role of aquaporins in transporting water.

In the earlier section, you learned that small polar molecules like water diffuse through the cell membrane. Simple diffusion alone cannot explain the rapid diffusion of large amounts of water. How do hydrophilic water molecules cross the hydrophobic interior of the bilayer? Are there structures that facilitate the entry of water into cells?

Integral and peripheral proteins

Proteins are vital components of biological membranes. Membrane proteins differ in location, structure and function.

Student view

Based on their association with the lipid bilayer, membrane proteins can be classified as:

- integral proteins
- peripheral proteins.

Integral proteins

As the term implies, integral membrane proteins are embedded in the lipid bilayer. These proteins are difficult to isolate as extraction techniques involve disrupting the bilayer. These integral proteins are amphipathic molecules. The hydrophobic regions of the integral proteins interact with the hydrophobic interior of the lipid bilayer, causing them to be embedded in the bilayer. The hydrophilic regions interact with the hydrophilic heads of the lipid bilayer or the aqueous environment.

Most integral proteins are transmembrane proteins, i.e. they extend across the membrane. Others are found only on one side of the bilayer.

Peripheral proteins

Unlike integral proteins, peripheral proteins are hydrophilic in nature and do not have hydrophobic regions. These proteins are normally found on the surface of the membrane and interact only with the hydrophilic regions of the integral proteins, and at times, with the hydrophilic heads of the phospholipids (**Figure 1**). Hence, it is easier to remove these molecules from biological membranes.

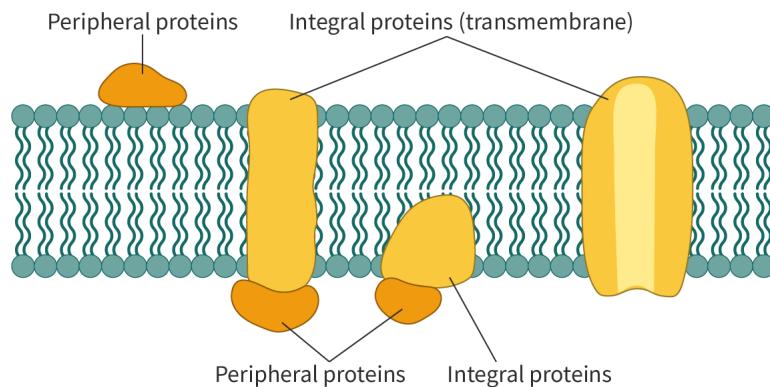


Figure 1. A schematic representation of membrane proteins.

More information for figure 1

The diagram shows a cross-section of a membrane with integral and peripheral proteins. The membrane is represented as a double-layer of small circular structures, symbolizing the lipid bilayer. Integral proteins, labeled as "integral proteins (transmembrane)," span the entire membrane, embedding themselves through it. There are two representations of these transmembrane proteins shown, with different shapes to suggest variability. They appear as vertical elongated oval shapes. Peripheral proteins, labeled as such, are shown attached to the membrane surface, not penetrating deeply into it. They are depicted semi-circularly and are situated on the outside of the lipid bilayer's surface. The overall layout demonstrates how these proteins are arranged in relation to the bilayer, illustrating their interaction dynamics and positioning.

[Generated by AI]

The membrane proteins – both integral and peripheral – are asymmetrically (unevenly) oriented across the lipid bilayer.



Functions of membrane proteins

Overview
(/study/app/422-cid-755105/)

Apart from their structural role, membrane proteins have other functions, as outlined below and in **Figure 2**.

- Transport proteins – Membrane proteins facilitate the movement of molecules in and out of the cell. These include both channel proteins and carrier proteins (see later in this section and [B2.1.6–8 \(/study/app/bio/sid-422-cid-755105/book/facilitated-diffusion-and-active-transport-in-id-44644/\)](#)). Channel proteins are transmembrane proteins that form channels or pores for the passage of molecules. Carrier proteins on the other hand undergo a conformational change to transfer the molecules from one side of the membrane to the other.
- Recognition – Membrane proteins help in cell–cell recognition acting as ‘name tags’ for the cells. This is essential, especially in the functioning of the immune system, as it helps to distinguish between self and non-self cells.
- Receptors – Membrane proteins act as receptors for chemical signals and are binding sites for molecules like hormones and neurotransmitters. Often, binding of these molecules triggers a chain of intracellular reactions.
- Enzymes – Membrane proteins show enzymatic activity and catalyse reactions. For example, glucose-6-phosphatase is a membrane-bound enzyme found in the endoplasmic reticulum.
- They can help in cell adhesion to other cells or to the environment (see [section B2.1.6–8 \(/study/app/bio/sid-422-cid-755105/book/facilitated-diffusion-and-active-transport-in-id-44644/\)](#)) and play a role in cell motility.

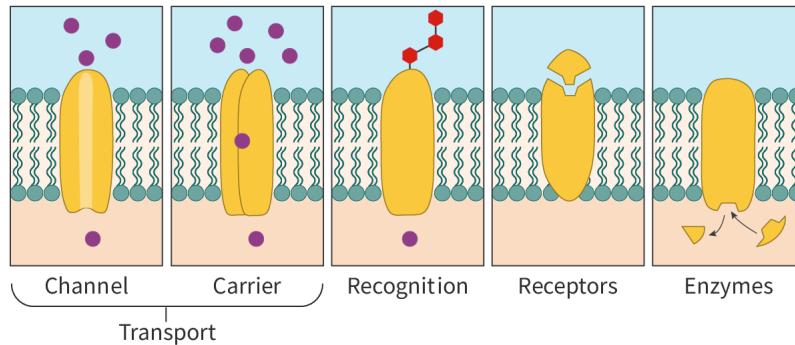


Figure 2. A simple illustration to show some of the functions of membrane proteins.

More information for figure 2

The image is a diagram illustrating five functions of membrane proteins, each represented in separate panels. The first panel shows a channel protein allowing small, purple molecules to pass through from the top to the bottom of the membrane. The second panel depicts a carrier protein transporting a purple molecule across the membrane. In the third panel, a recognition protein with a red molecular structure interacts with molecules outside the membrane. The fourth panel illustrates receptors with a distinct binding site interacting with molecules. The last panel shows an enzyme protein, with a substrate binding and a reaction resulting in broken pieces, depicting enzymatic activity. Below the panels, labels describe the functions as 'Channel,' 'Carrier,' 'Recognition,' 'Receptors,' and 'Enzymes,' collectively under the term 'Transport.'

[Generated by AI]

Osmosis

Place a few raisins in water and within a few hours, they swell. On the other hand, place a few grapes in a sugar solution for some time, and they become shrivelled. This is due to osmosis. Osmosis is the diffusion of water across a selectively permeable membrane from lower to higher solute concentrations. In general, the concentration of solutes tends to be higher within the cell than outside, resulting in the net movement of water into the cell.

Student view

As described in section B2.1.1–3 (/study/app/bio/sid-422-cid-755105/book/lipid-bilayers-id-44634/), the permeability of biological membranes to different substances depends on the size and polar nature of the molecules. This in turn creates two regions on either side of the membrane – a region with a higher solute concentration and a region with a lower solute concentration. Water diffuses from a region of lower solute concentration (and higher water concentration) to a region with higher solute concentration (and lower water concentration) through the membrane.

Figure 3 shows osmosis of water across a selectively permeable membrane from side X to side Y. The movement of water molecules continues until the solute concentration is the same on both sides of the membrane. It is important to remember that the membrane would be impermeable to polar solutes.

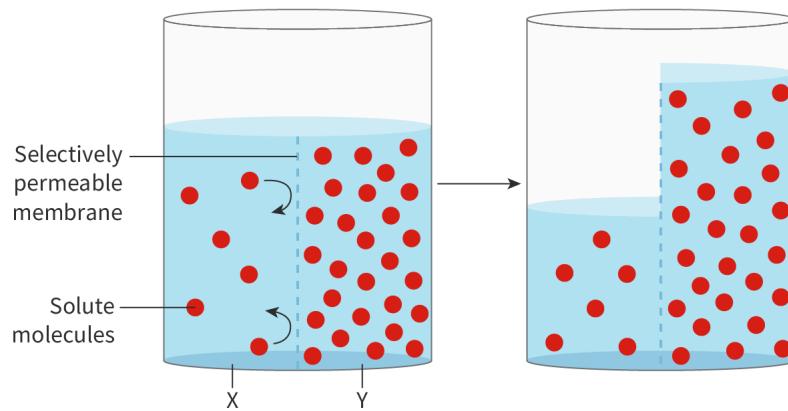


Figure 3. Osmosis.

More information for figure 3

The image is a diagram illustrating the process of osmosis. It shows two cylindrical containers, each divided by a selectively permeable membrane. In the container on the left, water molecules are moving from side X to side Y due to osmosis. Side X has fewer solute molecules compared to side Y. Arrows indicate the direction of water movement across the membrane, which is permeable only to water but not to the solute, depicted as red dots. The container on the right shows a dynamic equilibrium state where water levels have equalized, but the solute concentration remains different due to the impermeability of the membrane to solute molecules. Labels point to the selectively permeable membrane and solute molecules.

[Generated by AI]

Water always moves by osmosis from a region of higher water concentration to a region of lower water concentration. This continues until the concentration becomes the same on both sides of the membrane. Once this happens, although the random movement of water molecules continues, there is no *net* movement of water.

Aquaporins

The hydrophobic interior of the lipid bilayer does not allow the polar water molecules to pass through easily. Yet, the rates at which water molecules move across the cell membranes of some cells are far higher than what would be expected by mere diffusion. In 1992, Peter Agre and his colleagues discovered aquaporins (AQP), a type of channel protein, which explained this phenomenon.



Nature of Science

Overview
(/study/app/
422-
cid-
755105/o)

Aspect: Evidence

Scientists had been suggesting the existence of water channels back in the late 1800s. It was only when Peter Agre and his colleagues isolated the water channel proteins that these claims were verified. Scientific claims need to be supported by evidence and in this case, it was the discovery of aquaporins.

Aquaporins are integral proteins. A typical AQP molecule is a tetrameric protein composed of four monomeric subunits (see quaternary structure, [section B1.2.11 \(/study/app/bio/sid-422-cid-755105/book/summary-and-key-terms-id-44685/\)](#)). Each subunit has a water channel, so, an aquaporin molecule has four identical water channels (**Figure 4**).

The water channels are lined with specific hydrophilic side chains (of amino acid residues) which allows the passage of water molecules but not of ions. The water molecules pass in a single file through the channels, but, even then, several billion molecules pass through a single channel at one time.

It is important to remember that aquaporins are bidirectional, i.e. water can flow in either direction: into the interior or out to the exterior of the cell depending on the concentration gradient.

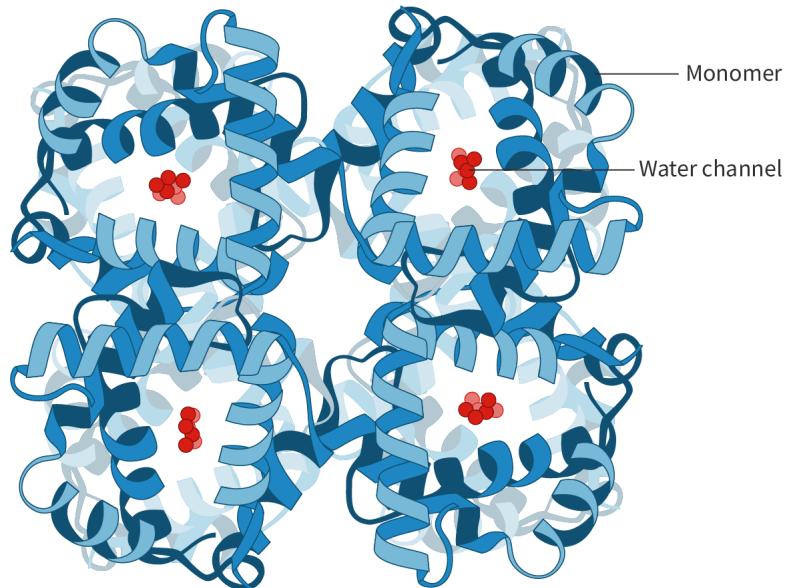


Figure 4. An aquaporin tetramer.

More information for figure 4

The image shows an illustration of an aquaporin tetramer structure. It depicts four monomer units arranged symmetrically, forming a tetramer. Each monomer is shown as a series of helices and loops represented by blue ribbon-like structures. The image highlights monomers and water channels, with the water channel labeled and located centrally in each monomer. The channels are indicated using red spheres or markers.

[Generated by AI]



Aquaporins thus permit the rapid movement of water in and out of the cell by forming hydrophilic channels that span across the membrane. The volume of water that needs to be transported across the cell membranes determines the number of aquaporins. For example, the cells of the kidney reabsorb water and hence, have a higher concentration of aquaporins.

Try this activity to compare peripheral and integral membrane proteins using a Venn diagram.

Activity

- **IB learner profile attribute:** Thinker
- **Approaches to learning:** Thinking skills — Reflecting at all stages of the assessment and learning cycle
- **Time required to complete activity:** 10–15 minutes
- **Activity type:** Individual activity

Instructions

Venn diagrams are concept diagrams that show similarities and differences often between related concepts. They help to organise and clarify concepts, bringing in a deeper understanding.

- Reflect on your learning by comparing the similarities and differences in integral and peripheral proteins.
- Make a Venn diagram either using [Canva](https://www.canva.com/graphs/venn-diagrams/) (https://www.canva.com/graphs/venn-diagrams/), or pen and paper. **Video 1** explains how to create the Venn diagram using Canva.

How to create venn diagram



0:00



Video 1. Creating a Venn Diagram.

 More information for video 1

The video provides a step-by-step tutorial for creating Venn diagrams in Canva. The video begins on Canva's home page. On the home page, the user enters a "Venn diagram" into the search bar, located on a small section on the left. This shows several Venn diagram templates below the search bar. The cursor hovers over various colorful Venn diagram templates and clicks on a pre-made template of two overlapping circles. Upon clicking, the selected template is displayed on the section located on the right. In the template, the left circle is labeled "Art", the right circle is labeled "Tech", and the overlapping section in the middle is labeled "Magic". There is a text box for the title above the Venn diagram. It already consists of the text that states: What two things together create magic for you?

The cursor then selects and removes the existing title and adds a new title: "The social media landscape". Further, the user edits the titles within the circles. In the left circle, the text "Art" is replaced with "Networking". In the right circle, the text "Tech" is replaced with "Entertainment". In the overlapping region between the two circles, the text "Magic" is replaced with "Social media". The font size of "Social media" is large and it occupies the space outside the overlapping region too. Hence, the user formats the font size. To do this, the user clicks the "Spacing" option on the toolbar located at the top and then moves the slider beside the "line-height" to adjust it to 0.9. The user then moves the cursor towards the font size option and changes the font size to 36.

Next, the user clicks the "Elements" tab located on the left-hand side of the canvas page. Clicking on this tab reveals a small section with the search bar on top along with some elements at the bottom. The user types "social media" into the search box. Several elements representing social media appear below the search bar. The user clicks on a bird icon and this bird icon appears in the middle of the Venn diagram page. There is a double-sided arrow at the top right corner of this bird image that can be used to increase or decrease the size of the image. The user reduces the size of the bird icon using this option and aligns it neatly in the center of the overlap area above the text "social media". Next, the user chooses the color option under the top menu to personalize the bird image color.

Lastly, the cursor clicks on the dropdown menu beside the "present" option at the top right corner of the screen. From the dropdown list, the user clicks on the "download" icon, selects "PDF standard" as the file type, and initiates the download process. A pop-up appears that reads, "Preparing your design", with an option "Cancel" to cancel the download if needed. Then another pop-up appears that reads, "Your design has been published". There is also a notice below the pop-up that states "Your download should have automatically started, if not, download here" with an active link at the part "download here". There are also two icons below that provide the user with options to continue editing or go to the homepage.

This video tutorial helps users to learn how to create a Venn diagram using Canva. After learning how to create a Venn diagram, the users are encouraged to create a Venn diagram of their own to compare the similarities and differences between integral and peripheral proteins.

5 section questions ▾

B2. Form and function: Cells / B2.1 Membranes and membrane transport

Facilitated diffusion and active transport in selective permeability of membranes

B2.1.6: Channel proteins for facilitated diffusion B2.1.7: Pump proteins for active transport B2.1.8: Selectivity in membrane permeability

Section

Student... (0/0)

Feedback



Print (/study/app/bio/sid-422-cid-755105/book/facilitated-diffusion-and-active-transport-in-id-44644/print/)

Assign

Learning outcomes

By the end of this section you should be able to:

- Describe the structure and role of channel proteins.
- Explain the importance of pump proteins in active transport.
- Explain the role of facilitated diffusion and active transport in the selective permeability of membranes.

Imagine your hands are loaded with packages. You are wondering how to push open the door. But then, you see that the door ahead is a swivel door that would spin and would allow you to pass through without too much effort. A similar mechanism exists within cells to transport molecules across the cell membrane. How do these mechanisms work?

Facilitated diffusion

Diffusion is the movement of solutes down their concentration gradient. However, even down the concentration gradient, the size or the polar nature of most molecules prevents them from crossing the cell membrane. The movement of these molecules is mediated by proteins which could be either carrier or channel proteins.

This type of movement is called facilitated diffusion, because:



- the movement of the molecules is down the concentration gradient
- the movement is assisted (facilitated) by transport proteins.

Overview

(/study/app

422-

cid-

755105/o

Facilitated diffusion aided by channel proteins

Channel proteins, as the term implies, are transmembrane proteins that assemble to form channels for the passage of polar molecules. One example are ion channels, the tiny pores of which act as pathways for ions like Na^+ and K^+ . These channels are highly selective and often, different channels are needed for the transport of different ions.

The selectivity of the ion channels is due to:

- the binding sites of the hydrophilic amino acid side chains lining the channel being highly ion-specific
- the size of the pore acting as a size filter.

Most channels open or close in response to specific stimuli, such as:

- changes in voltage across the membrane or voltage-gated channels
- binding of small molecules to the channel proteins or ligand-gated channels
- mechanical forces like pressure.

Hence, ion channels in facilitated diffusion are gated (see section [B2.1.14–16 \(/study/app/bio/sid-422-cid-755105/book/more-about-transport-mechanisms-hl-id-44647/\)](#)). When the gates are open, the ions pass through the pore down the concentration gradient. On the other hand, in a closed state, the pore is plugged, preventing the passage of the ion (**Figure 1**).

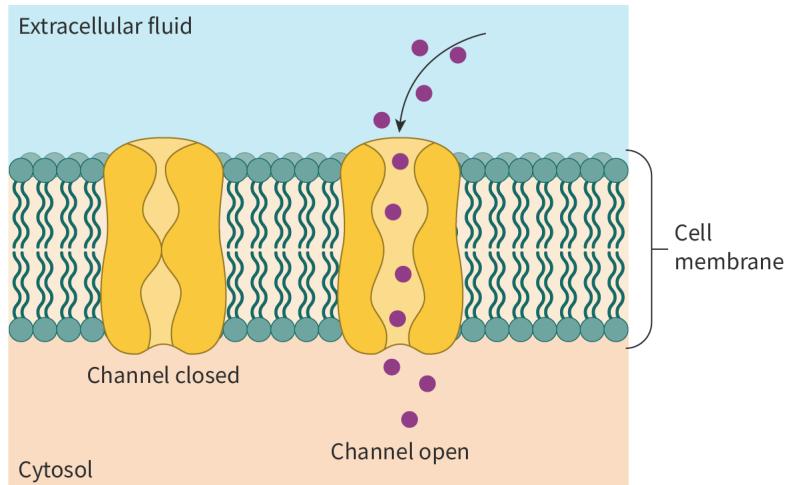


Figure 1. Facilitated diffusion via ion channels.

More information for figure 1

This diagram illustrates the process of facilitated diffusion via ion channels in a cell membrane. There are two main sections depicted: one shows the ion channel in a closed state, and the other shows it in an open state. The cell membrane is represented with a structure of lipid bilayers, where the outer layer faces the extracellular fluid and the inner layer faces the cytosol. When the ion channel is open, ions are depicted as small purple circles moving from the extracellular fluid into the cytosol through the open channel. The diagram visually explains how the gated ion channels work, allowing ion passage when open, and blocking it when closed.

[Generated by AI]



Overview
 (/study/app/
 422-
 cid-
 755105/o)

Porins are another example of channel proteins. These channels tend to be less specific and are larger.

Facilitated diffusion aided by carrier proteins

Like channel proteins, carrier proteins are transmembrane transport proteins that play an important role in facilitated diffusion. However, the mechanism is very different. The carrier protein binds to the solute molecules (molecules to be transported), undergoes a conformational change and transfers the molecules to the other side of the membrane (**Figure 2**). Carrier proteins have sites specific for the solute or class of solutes to be transported and hence are highly specific. One example is the GLUT or glucose transporter, a carrier protein that helps in the transport of glucose into the red blood cell (RBC) down its concentration gradient.

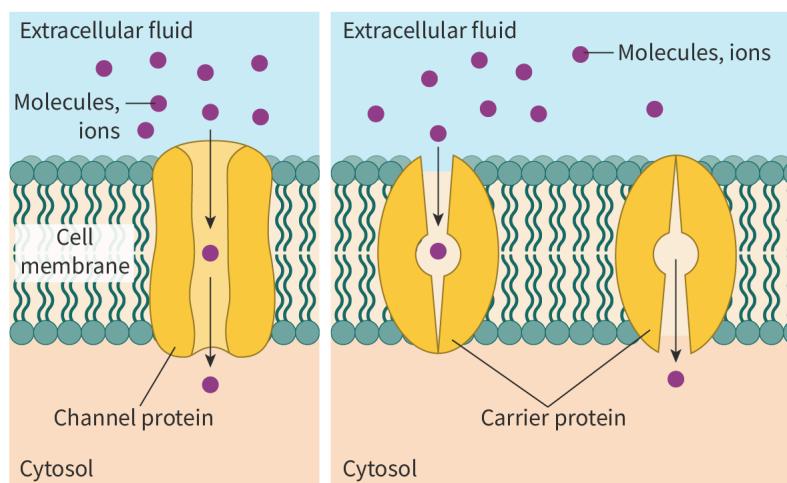


Figure 2. Facilitated diffusion with the help of carrier proteins.

More information for figure 2

The diagram shows two types of facilitated diffusion involving a cell membrane separating the extracellular fluid from the cytosol. On the left, a channel protein spans the membrane, allowing molecules or ions from the extracellular fluid to flow directly through the open channel into the cytosol. On the right, a carrier protein initially binds with a molecule or ion in the extracellular fluid and undergoes a conformational change to transport it across the membrane into the cytosol. The carrier protein shows a more complex interaction as it encloses the molecule or ion before release. The diagram labels include 'Extracellular fluid,' 'Molecules, ions,' 'Cell membrane,' 'Channel protein,' 'Carrier protein,' and 'Cytosol.' Arrows indicate the direction of molecule movement through the proteins, emphasizing the transport mechanism differences between the channel and carrier proteins.

[Generated by AI]

Video 1 shows an animation of facilitated diffusion mediated by channel and carrier proteins.



Student
view

Detailed Animation on Facilitated Diffusion



Video 1. Facilitated diffusion aided by channel and carrier proteins.

Active transport and pump proteins

Imagine a waterfall. Water cascades down. On the other hand, if water has to be transported to the top of a building, it has to be pumped to overcome the force of gravity. A similar situation exists in cells: when ions or molecules have to be moved against their concentration gradient they need to be pumped.

Active transport comes into play when molecules need to be transported from a region of their lower concentration to a region of their higher concentration, i.e. against their concentration gradient. As the transport is ‘uphill’, energy is required. In other words, the transport of the molecules is coupled with an energy-releasing or exergonic reaction like the breakdown of ATP.

The transport proteins used for active transport are often called pumps as they move the molecules against their concentration gradient (**Figure 3**).

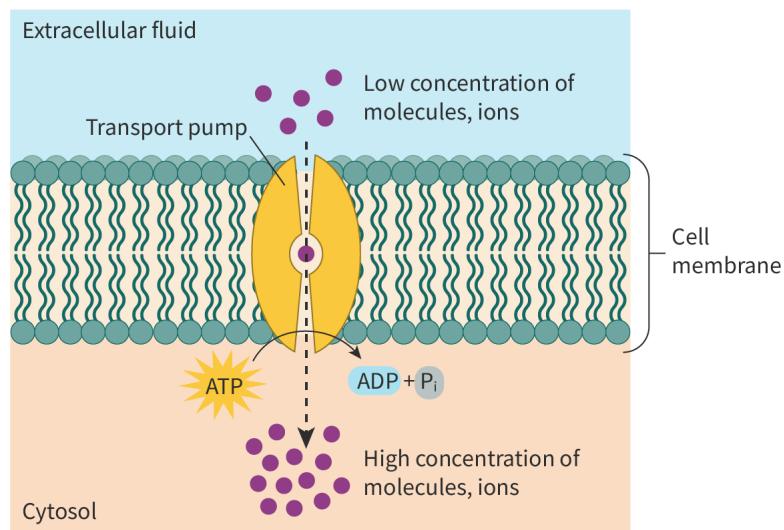


Figure 3. Active transport.

More information for figure 3

The image is a diagram illustrating active transport across a cell membrane. It depicts the cell membrane as a double layer with embedded proteins called transport pumps. On one side, labeled as the extracellular fluid, there is a low concentration of molecules and ions, while on the other side, labeled as the cytosol, there is a high concentration. The transport pump in the membrane uses ATP (adenosine triphosphate) to move molecules from the area of low

concentration to high concentration, against the concentration gradient. The transformation of ATP into ADP (adenosine diphosphate) and a phosphate group is indicated, highlighting the energy expenditure required for this process. The labeled parts also include the cell membrane and the flow of molecules and ions.

[Generated by AI]

Active transport helps to:

- take up essential nutrients – an example is the uptake of glucose from the lumen of the intestine to the epithelial cells lining the small intestine (see [section B2.1.14–16 \(/study/app/bio/sid-422-cid-755105/book/more-about-transport-mechanisms-hl-id-44647/\)](#))
- remove secretory or waste materials from the cell into the extracellular fluid
- maintain the right concentrations of ions in the cells; for example, active transport helps red blood cells (RBCs) maintain their internal sodium and potassium levels.

⊕ Study skills

The mode of transport of glucose changes depending on the concentration gradient and the transport proteins involved. Glucose is transported across the cell membrane using transport proteins like GLUTs or sodium-dependent glucose cotransporters (SGLTs) (see [section B2.1.14–16 \(/study/app/bio/sid-422-cid-755105/book/more-about-transport-mechanisms-hl-id-44647/\)](#)). However, GLUTs help in facilitated diffusion whereas SGLTs help in active transport.

Types of active transport

There are two main types of active transport.

- Direct active transport is where the energy released by an exergonic reaction like the breakdown of ATP is used to directly transport molecules across the cell membrane (see [section B2.1.14–16 \(/study/app/bio/sid-422-cid-755105/book/more-about-transport-mechanisms-hl-id-44647/\)](#)). As energy is derived by the hydrolysis of ATP, these transport proteins are called ATPases or ATPase pumps.
- Indirect active transport or cotransport, where the movement of one solute down its concentration gradient drives the movement of the second solute against its concentration gradient (see [section B2.1.14–16 \(/study/app/bio/sid-422-cid-755105/book/more-about-transport-mechanisms-hl-id-44647/\)](#)).

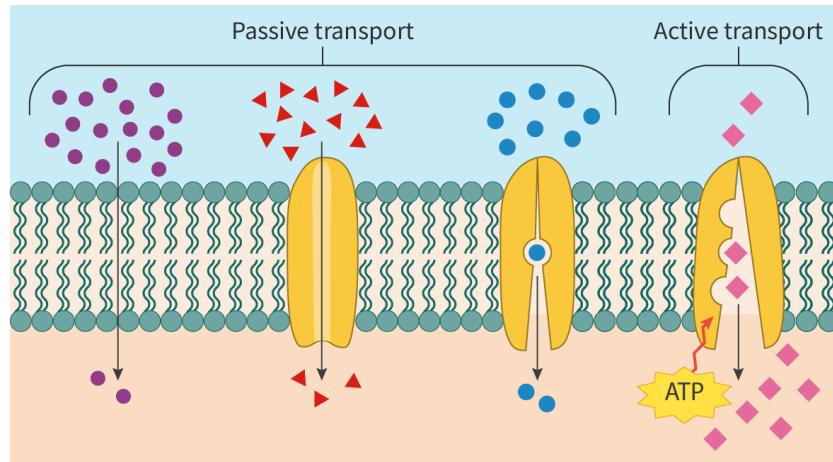
Video 2 outlines how active transport differs from diffusion.

Home
Overview
(/study/app-
422-
cid-
755105/o

Transport In Cells: Active Transport | Cells | Biology | FuseSchool

**Video 2.** Active transport in cells.

Interactive 1 shows the different forms of membrane transport. Drag and drop to match the terms with the images.



Facilitated diffusion using channel proteins

Active transport

Simple diffusion

Facilitated diffusion using carrier protein

Check

Interactive 1. Membrane Transport.

More information for interactive 1

The interactive illustrates two main categories of membrane transport: Passive transport (on the left) and Active transport (on the right), separated by a vertical imaginary line. Both occur across a cell membrane, depicted as a teal and light green striped region representing the phospholipid bilayer. The area above the membrane is light blue, representing the extracellular space, and the area below is light brown, representing the intracellular space.

Passive transport present on left side:

This section shows three types of passive transport, where substances move across the membrane without the cell expending energy, typically down their



concentration gradient.

Overview
(/study/app/
422-
cid-
755105/o

The first substance (several purple circles) present in high concentration above the membrane. A straight black arrow indicates one purple circle moving directly through the phospholipid bilayer and appearing in lower concentration of the first substance below the membrane.

The second substance (several red triangles) present in high concentration above the membrane. A yellow, tunnel-shaped protein channel spans the membrane. Black arrows show the red triangles moving through this channel, resulting in a lower concentration of second substance below the membrane.

The third substance (several blue circles) present in high concentration above the membrane. A yellow protein with a binding site is shown. A blue circle binds to this site, causing the protein to change shape and release the blue circle on the other side of the membrane, resulting in a lower concentration of the third substance below.

Active Transport on the Right Side

This section shows one type of active transport, where the cell expends energy or ATP to move substances across the membrane against their concentration gradient.

The substances that are in low concentration above the membrane are present in high concentration below the membrane. A yellow protein pump spans the membrane. A jagged yellow shape labeled "ATP" is shown providing energy to the pump. Black arrows indicate the substances above the membrane being moved by the pump from the region of lower concentration (above) to the region of higher concentration (below), requiring energy input from ATP. The image clearly contrasts passive transport, driven by concentration differences and not requiring cellular energy, with active transport, which requires energy or ATP to move substances against their concentration gradient.

There are four blanks given below this interactive. The drag-and-drop options for these blanks are given below the image. They are: facilitated diffusion using channel proteins, active transport, simple diffusion and facilitated diffusion using carrier protein.

Read below for the solution:

Answer from left to right:

First substance in passive transport moves by simple diffusion, second substance in passive transport moves by facilitated diffusion using carrier protein, and the third substance in passive transport moves by Facilitated diffusion using channel proteins. The last blank to be filled with active transport as the substances in active transport moves by active transport.

Selectivity in membrane permeability

It is evident that biological membranes are designed in a way to let some molecules in and keep out others.

The movement of molecules by simple diffusion is based on two factors: the size of the molecules and their hydrophobic or hydrophilic nature. In other words, the permeability of the membrane depends on the physical properties of the molecules. Any molecules that fit these criteria, irrespective of whether they are useful or harmful, pass through the cell membrane. Thus, in the instance of simple diffusion, permeability of the cell membrane is not selective.

However, facilitated diffusion and active transport involve proteins that transport molecules from one side of the membrane to the other. These transport proteins, whether channel proteins or carrier proteins, exhibit selectivity as they recognise specific molecules or classes of molecules. For example:

- Gated ion channels like calcium-specific ion channels in muscle cells regulate the movement of calcium ions alone.
- Carrier proteins are highly specific. For example, GLUT (glucose transporter) recognises and binds only to glucose and a few other monosaccharide molecules.

The selective permeability of the membrane is hence due to facilitated diffusion and active transport.

Try this role-play activity to compare the different types of membrane transport described in this section.



Student
view

Activity

- **IB learner profile attribute:** Communicator
- **Approaches to learning:** Communication skills — Clearly communicating complex ideas in response to open-ended questions
- **Time required to complete activity:** 30 minutes
- **Activity type:** Group activity

Instructions

- Form three groups. Select one of the three mechanisms, i.e. simple diffusion, facilitated diffusion or active transport to simulate. Enact a role-play that accurately depicts the mechanism you have selected.
- Read through the relevant text to familiarise yourselves with the process of membrane transport.
- Discuss and come up with creative yet accurate ways to present the mechanism.
- Assign roles within the group. Based on the mechanism selected, some of the roles could be cell membrane/lipid bilayer, oxygen molecule, transport proteins, transport pump, ATP, ion, etc. (note that all the roles may not be applicable to one mechanism).
- Check the assessment rubric in **Table 1** and clarify any doubts with your teacher.
- Practise the role-play.
- Present in class.

Table 1. Rubric.

Criteria	Exceeding	Meeting	Approaching
Accuracy	High accuracy, good understanding of the topic.	More or less accurate, fairly good understanding of the topic.	Many errors, poor understanding of the topic.
Presentation	All group members speak clearly, use the correct terminology, the flow of scenes is logical.	Most group members speak clearly, the terminology used is mostly correct, the flow of scenes is more or less logical.	Few members speak clearly, the terminology used is not accurate, flow of scenes is not sequential.
Cooperation	All the members stayed on task, and contributed equally.	Most of the members stayed on task.	A lack of cooperation was seen, with the efforts being led by one or two students.

5 section questions ▾

B2. Form and function: Cells / B2.I Membranes and membrane transport

Fluid mosaic model

B2.I.9: Glycoproteins and glycolipids B2.I.10: Fluid mosaic model of membrane structure

Section	Student... (0/0)		Feedback		Print (/study/app/bio/sid-422-cid-755105/book/fluid-mosaic-model-id-44645/print/)	Assign
----------------	------------------	--	-----------------	--	--	---------------

Student view

Learning outcomes

By the end of this section you should be able to:

- Describe glycoproteins and glycolipids with respect to their structure and function.
- Draw the fluid mosaic model of membrane structure.

Glycolipids and glycoproteins

In addition to phospholipids and proteins, most membranes also consist of small amounts of carbohydrates. These carbohydrates are either linked to lipids – forming glycolipids, or linked to proteins – forming glycoproteins.

Glycolipids

The covalent bonding of carbohydrates to lipids results in glycolipids. Vital parts of the cell membranes, glycolipids are amphipathic molecules, often restricted to the external surface of the cell membrane. The carbohydrate groups of these molecules are polar and extend into the extracellular environment, whereas the non-polar lipid component lies embedded in the bilayer.

Based on their structure, glycolipids are classified into

- glycoglycerolipids or glycerol-based lipids
- glycosphingolipids or derivatives of sphingosine; examples include cerebrosides and gangliosides.

Glycolipids contribute to membrane stability as they form hydrogen bonds with the water molecules surrounding the cell.

Glycoproteins

The covalent bonding of oligosaccharides (short carbohydrate chains) to the protein molecules results in the formation of glycoproteins. The carbohydrate groups of the glycoproteins often protrude (stick out) into the extracellular environment.

Functions of glycolipids and glycoproteins

Cell recognition: Glycolipids and glycoproteins play an important role in cell recognition. They act as ‘markers’ on the cell surface and help cells of the body recognise each other. They also help cells of the immune system to recognise foreign cells.

Cell adhesion: Both glycolipids and glycoproteins help cells to attach and bind to other cells to form tissues. Cell-adhesion molecules or CAMs (see [section B2.1.17 \(/study/app/bio/sid-422-cid-755105/book/cams-and-cell-adhesion-hl-id-44648/\)](#)) are cell-surface glycoproteins that play an important role in cell adhesion.

Cell signalling: They act as receptors for enzymes and other molecules helping in cell signalling, i.e. receiving and transmitting chemical signals.

Figure 1 shows how the type of antigens (glycolipids and glycoproteins) present on the surface of the red blood cell membranes determines blood groups.



Home
Overview
(/study/app/
422-
cid-
755105/o)

	Group A	Group B	Group AB	Group O
Red blood cell type				
Antigens on red blood cell surface	●	◆	● ◆	None

Figure 1. Blood groups are determined by the type of antigens (glycolipids and glycoproteins) present on the surface of the red blood cell membranes.

More information for figure 1

The diagram illustrates the blood groups A, B, AB, and O, each with specific antigens on red blood cell surfaces. It is organized in a grid layout. Each blood group is represented by a red circle symbolizing a red blood cell, surrounded by distinct markers depicting antigens.
Group A: Red blood cell with purple circular markers on the surface.
Group B: Red blood cell with green diamond-shaped markers on the surface.
Group AB: Red blood cell with both purple circular and green diamond-shaped markers, indicating the presence of both antigens A and B.
Group O: Red blood cell with no markers, indicating the absence of antigens A and B.
This demonstrates how the presence or absence of these antigens classifies the blood into different groups.

[Generated by AI]

Glycocalyx: The glycocalyx (**Figure 2**) is the sticky layer formed by the carbohydrate groups of the glycolipids and glycoproteins that protrude from the cell surface. The glycocalyx in addition to its roles in cell signalling, cell adhesion and cell-cell recognition, helps in protecting the cell surface.

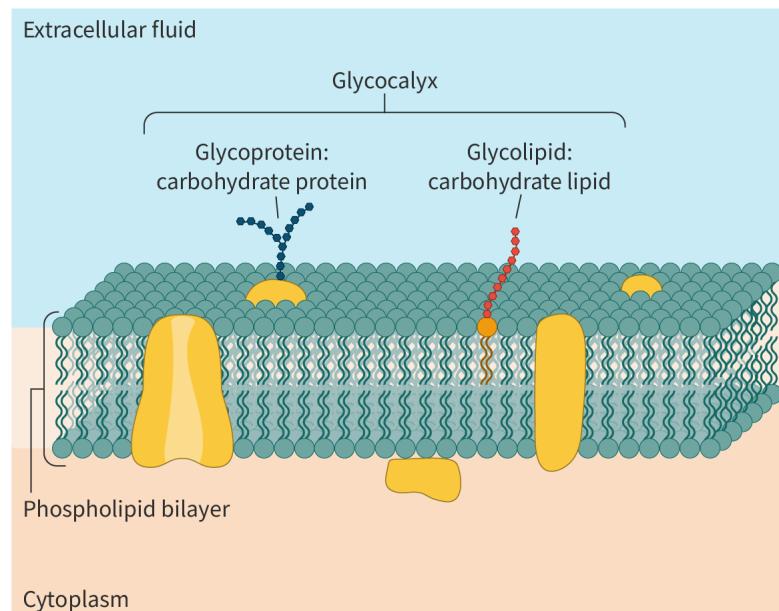


Figure 2. Glycolipids and glycoproteins.

More information for figure 2

The image illustrates the structure of a cell membrane, highlighting the glycocalyx, phospholipid bilayer, and locations of glycolipids and glycoproteins. At the top, the label 'Extracellular fluid' indicates the area outside the cell. Below is the 'Glycocalyx' which encompasses both glycoproteins and glycolipids. The glycoprotein is labeled 'Glycoprotein:'.

X
Student view



Overview
(/study/app/
422-
cid-
755105/o

carbohydrate protein' and is depicted as a structure with a carbohydrate extending from a protein. On the right, 'Glycolipid: carbohydrate lipid' is depicted as a carbohydrate chain extending from a lipid. These elements protrude from the phospholipid bilayer, which is shown as a double layer of phospholipids with hydrophilic heads and hydrophobic tails. The section labeled 'Cytoplasm' indicates the interior of the cell. The phospholipid bilayer also includes integral proteins that pass through its structure.

[Generated by AI]

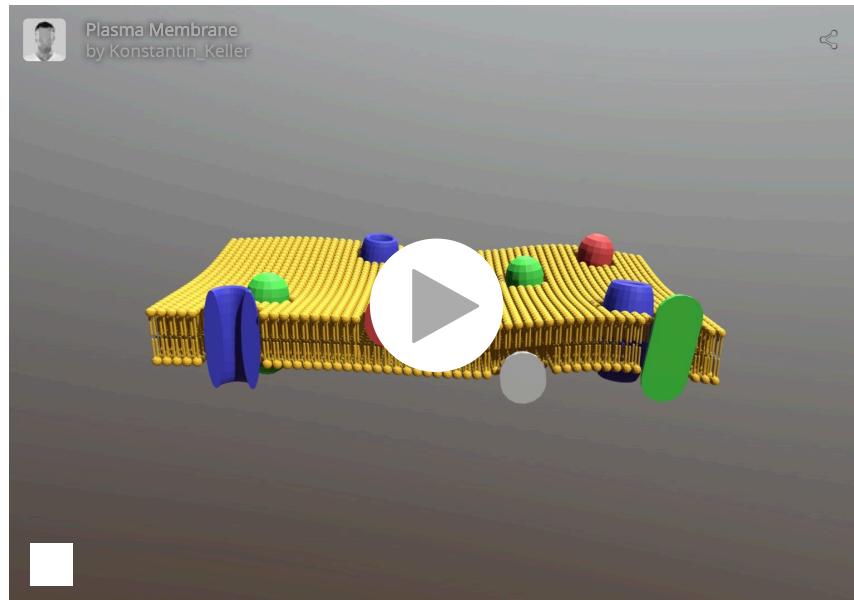
Fluid mosaic model

The fluid mosaic model of membrane structure was proposed by Singer and Nicolson in 1972 and describes the arrangement of the lipids and proteins. The model (**Interactive 1**) states that:

- the lipid bilayer is fluid – the fluidity of the membrane depends on the nature of the fatty acids in the phospholipid molecules and the amount of cholesterol (see [section B2.1.11–13 \(/study/app/bio/sid-422-cid-755105/book/membrane-fluidity-hl-id-44646/\)](#))
- the proteins (both integral and peripheral) are embedded in the fluid bilayer which resembles a mosaic.

The fluid nature of the membrane means that most of the lipids and proteins are able to move laterally, parallel to the membrane surface. Thus, according to the fluid mosaic model, the membrane is organised as a mosaic of proteins present within a fluid lipid bilayer.

The fluid mosaic model provides a framework to understand membrane structures; however, research continues to enhance our understanding and explain new findings.



Interactive 1. The fluid mosaic model of membrane structure.

[More information for interactive 1](#)

This interactive 3D visualization of the fluid mosaic model of the cell membrane illustrates the structure and organization of its components, a vital part of all living cells.



Home
Overview
(/study/app/
422-
cid-
755105/o

The yellow spheres represent the phospholipid bilayer, the foundation of the membrane. Each phospholipid molecule has a hydrophilic (water-loving) head and a hydrophobic (water-fearing) tail, which organize into two layers with the tails facing inward. This arrangement creates a selective barrier that regulates what enters and exits the cell. The bilayer is depicted as a dynamic and fluid structure, allowing molecules to move laterally.

Membrane proteins, represented by colorful structures, are embedded within the bilayer and play essential roles in cell function. The blue cylindrical structures depict integral proteins, which span the bilayer and facilitate transport and signaling. The red spheres represent cholesterol molecules, which help maintain membrane fluidity and stability. The green cylindrical structures represent carbohydrates, which are involved in cell recognition and communication, acting like identification tags. Carbohydrates attached to proteins are called glycoproteins, while those attached to lipids are called glycolipids.

The fluid nature of the membrane arises from the constant movement of lipids and proteins within the bilayer. This movement reinforces the concept that the membrane is not a static structure but a dynamic and adaptable one, essential for cellular function. This model highlights the mosaic and dynamic nature of the cell membrane, demonstrating how its components work together to regulate cellular processes, maintain internal stability, and interact with the environment.

🔗 Nature of Science

Aspect: Falsification

Scientific knowledge is often tentative and based on available evidence. New evidence often leads to falsification of existing models or theories.

Research on the structure of the cell membrane has been going on for many years. Multiple models have been proposed like the Davson and Danielli model or the Robertson model. While each of these models were refinements of earlier models, advances in technology revealed shortcomings which eventually led to the models being discarded. Even now, although the fluid mosaic model is widely accepted among the scientific community, research goes on to refine and extend the same.

⚖ Theory of Knowledge

Why is it important to learn about models and theories that were falsified?

There have been multiple models to explain the structure of the membrane. Each of these models not only provides valuable insights into membrane structure and function, but also to the development of scientific thought. An understanding of the historical context, the availability of evidence and reasons for discreditation of theories/models plays an important role in shaping future scientific learning. In addition, discredited theories stimulate scientists to explore new hypotheses.

Drawing the fluid mosaic model

The fluid mosaic model is straightforward to draw. Follow **Interactive 2** for a quick recap of the key concepts.

✖
Student
view



Overview
(/study/app/
422-
cid-
755105/o

Interactive 2. Drawing the Fluid Mosaic Model.

More information for interactive 2

This interactive slideshow provides a structured, visual walkthrough of the Fluid Mosaic Model of the cell membrane, using a step-by-step approach that supports inclusive learning. The interactive consists of a total of seven slides, each providing structures and instructions that guide viewers to draw the fluid mosaic model.

The first slide introduces the symbolic representations of all key components used throughout the slideshow. Phospholipids are shown as blue circular heads with two flexible, ribbon-like tails, representing their hydrophilic and hydrophobic regions. Carbohydrate structures include glycoproteins, shown as yellow units with blue, thread-like extensions ending in beads, and glycolipids, represented as red threads with bead-like ends, both located on the outer membrane surface. Cholesterol appears as small, round yellow dots, symbolizing its embedded position between phospholipid tails. Integral proteins are depicted as tall, yellow cylinders that pass completely through the membrane, while channel proteins are shown as thick, tube-like structures with a visible tunnel, indicating the passage of molecules. Transport proteins are elliptical in shape with an opening in the center, and peripheral proteins are slightly flattened, orange shapes that get attached to either surface of the membrane. The bottom of the slide consists of the text "Use the symbols to represent phospholipids, integral and peripheral proteins, glycoproteins, glycolipids, and cholesterol."

In the second slide, viewers see how the phospholipid bilayer is formed. The phospholipids are arranged in two opposing layers, with the blue circular heads on top facing the extracellular environment and the circular heads on the bottom layer facing the cytoplasm. The ribbon-like tails of phospholipids are facing inward toward each other. This forms the selective barrier that defines the membrane's semi-permeable nature. There are gaps in between the phospholipid bilayer, where other components of the fluid mosaic model will be inserted later. The text at the bottom of the slide states "Draw the lipid bilayer. Make sure to leave spaces between to insert the other components."

The third slide focuses on embedding various proteins into the bilayer. Integral, transport, and channel proteins are shown inserted across the full membrane thickness, while peripheral proteins are placed loosely on either the internal or external surface. This slide highlights how proteins contribute to structural support, molecular transport, and cellular communication. The text at the bottom of the slide states "Draw the roughly oblong integral and peripheral proteins."

In the fourth slide, cholesterol molecules are carefully positioned between the phospholipid tails, showing how they reduce membrane rigidity and maintain flexibility, especially in changing temperatures. The text at the bottom of the slide states "Add cholesterol."

The fifth slide demonstrates the placement of glycoproteins and glycolipids. Glycoproteins and glycolipids are placed on the membrane's extracellular surface, their bead-tipped extensions reaching outward. These structures help the cell identify other cells, send and receive signals, and interact with its environment. The text at the bottom of the slide states "Draw the glycolipids and glycoproteins on the outer surface of the cell membrane."



Student
view

Home
Overview
(/study/app/
422-
cid-
755105/o

The sixth slide shows the complete structure of the fluid mosaic model, with labelled parts. The labelled parts of the fluid mosaic model include channel protein, glycoprotein, glycolipid, integral protein, phospholipid bilayer, peripheral protein, cholesterol, and transport protein. The text at the bottom of the slide states "Label all the components."

The seventh and final slide shows the complete structure of the fluid mosaic model, along with two additional labels: The circular heads of phospholipid molecules labelled as "hydrophilic heads" and the tails of phospholipid molecules labelled as "hydrophobic tails". The text at the bottom of the slide states "Label hydrophobic and hydrophilic regions."

Each slide is visually distinct and methodically builds on the previous one, helping learners understand not just what each component is, but how all parts come together to form a dynamic, functional fluid mosaic model. The clear visuals, symbolic cues, and logical progression in the interactive slideshow make it easy for viewers to learn how to draw a fluid mosaic model. By the end of the slideshow, learners can recognize the arrangement and purpose of each molecule, the membrane's fluid and mosaic-like nature, and understand how different proteins and molecules contribute to the membrane's roles in protection, transport, and communication.

Try this modelling activity to check your understanding of the fluid mosaic model of membrane structure.

Activity

- **IB learner profile attribute:** Communicator
- **Approaches to learning:** Social skills — Working collaboratively to achieve a common goal
- **Time required to complete activity:** 30 minutes
- **Activity type:** Group activity

Prepare a 3D model depicting the fluid mosaic model.

Materials

Clay, twine, metal springs, paper of different colours, toothpicks, metal wire, any other waste material.

Instructions

- Form groups of four.
- Revise the concept either by watching **Video 1** or reading the text.
- Discuss and plan on the features to be included in the model, resources needed, etc.
- Create the model. Make sure that all the important features like the lipid bilayer of phospholipids, cholesterol, peripheral and integral proteins, glycoproteins, glycolipids, hydrophobic and hydrophilic regions are included.
- Display and present in class.

X
Student
view

Home
Overview
(/study/app/422-cid-755105/o)

Fluid mosaic model | Cells | Biology | FuseSchool



Video 1. Fluid mosaic model.

5 section questions ▾

B2. Form and function: Cells / B2.1 Membranes and membrane transport

Membrane fluidity (HL)

B2.1.11: Membrane fluidity and fatty acid composition (HL) B2.1.12: Membrane fluidity and cholesterol (HL) B2.1.13: Membrane fluidity and vesicles (HL)

Section

Student... (0/0)

Feedback



Print (/study/app/bio/sid-422-cid-755105/book/membrane-fluidity-hl-id-44646/print/)

Assign

Higher level (HL)

Learning outcomes

By the end of this section you should be able to:

- Describe the role of lipids in membrane fluidity.
- Discuss the role of cholesterol in membrane fluidity.
- Differentiate between exocytosis and endocytosis.

Poikilotherms are cold-blooded animals and their body temperature tends to conform to the outside temperatures. Any temperature changes would affect the rates of biological processes as well as the structure of biological molecules. Polar fish live in temperatures in freezing waters while desert insects and reptiles face scorching heat. How would these variations in temperature affect membrane structure and function? How do membranes continue to function in very low or high temperatures?

Membrane fluidity depends on the fatty acid composition of the phospholipids

All membrane lipids, whether phospholipids or glycolipids, have two long fatty acid chains. These fatty acid chains are hydrophobic in nature.

The fatty acids of the membrane lipids vary in length and in the number of double bonds.

Student view

- The number of carbon atoms in the fatty acid side chains of membrane lipids normally ranges from 16 to 20, resulting in variations in length of the fatty acids.

- The fatty acids also vary in their degree of saturation. Some fatty acids — like palmitic acid and stearic acid — seen in the membrane lipids are saturated ([section B1.1.8—11 \(/study/app/bio/sid-422-cid-755105/book/properties-and-functions-of-lipids-id-44588/\)](#)), i.e. there are no double bonds between the carbon atoms. Others — like oleic acid — are unsaturated with one or more double bonds between the carbon atoms.

The saturated fatty acids, with their higher melting points, provide stability to the membrane. The unsaturated fatty acids, with their lower melting points, ensure the fluidity of the membrane (**Figure 1**).

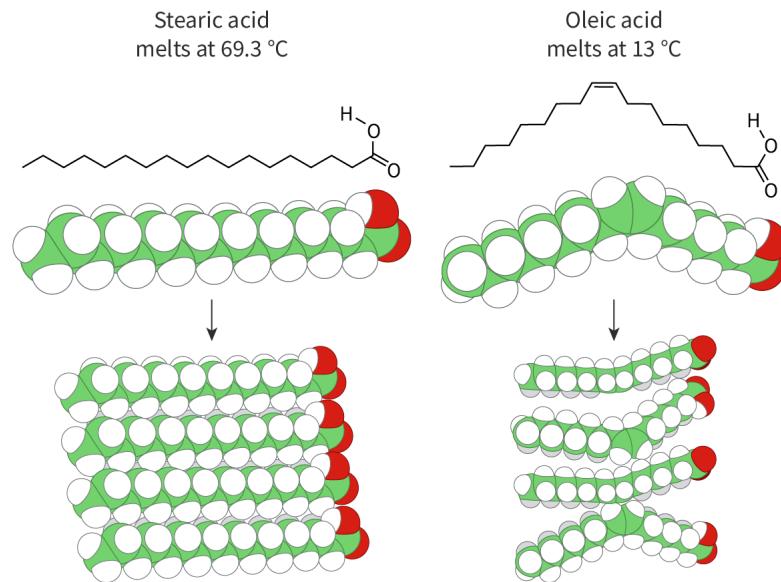


Figure 1. Saturated and unsaturated fatty acids.

[More information for figure 1](#)

The image is an illustration showing the difference between saturated and unsaturated fatty acids.

On the left, it depicts stearic acid, which is a saturated fatty acid. The top part of the section shows the linear molecular structure of stearic acid, with a straight chain. Below it, a 3D model highlights how the molecules pack tightly together due to their straight shape, resulting in a dense, ordered structure. This is associated with a higher melting point, labeled as melting at 69.3 °C.

On the right, the image illustrates oleic acid, an unsaturated fatty acid. The molecular structure at the top has one double bond, creating a bend or kink in the chain. The 3D model beneath it shows how the kinks prevent tight packing, resulting in a more disordered, fluid structure. The melting point is lower, labeled at 13 °C.

This visual comparison highlights how molecular shape affects the physical properties like melting point and structural arrangement of these fatty acids.

[Generated by AI]

You can see in **Figure 1** that unsaturated fatty acids have kinks in their chains whereas the ones with saturated fatty acids do not. As their fatty acid chains lie parallel to each other, lipids with saturated fatty acids fit together snugly, making the membrane denser and more rigid. On the other hand, the kinks prevent membrane lipids with unsaturated fatty acids from packing together closely, maintaining fluidity.

What happens when the temperature drops? At low temperatures, the phospholipid molecules come closer together, making the membrane more ‘gel-like’ and decreasing fluidity. This is where the ‘space’ created due to the kink in the tails becomes important – it prevents the molecules from packing too closely together and helps to maintain the membrane fluidity. Thus, saturated fatty acids freeze more easily than unsaturated fatty acids.

Cold-blooded organisms like frogs adapt to lower temperatures by increasing the proportion of unsaturated fatty acids in their membranes thereby regulating the fluidity. A similar example is seen in hibernating animals.

During hibernation, as the body temperature of the mammal drops, the proportion of unsaturated fatty acids in



the membrane phospholipids increases.

Membrane fluidity depends on cholesterol in animal cells

Cholesterol plays an important role in the fluidity of biological membranes. Cholesterol is an amphipathic steroid (see [section B1.1.12-13 \(/study/app/bio/sid-422-cid-755105/book/phospholipid-bilayer-id-44683/\)](#)). The hydrophobic region comprises four steroid rings and a hydrocarbon side chain; the hydrophilic region is a polar hydroxyl group (**Figure 2**). Found in one of the two layers, the hydrophilic and hydrophobic regions of a cholesterol molecule interact with the corresponding hydrophilic and hydrophobic regions of adjacent phospholipid molecules. These interactions hold the phospholipid molecules together.

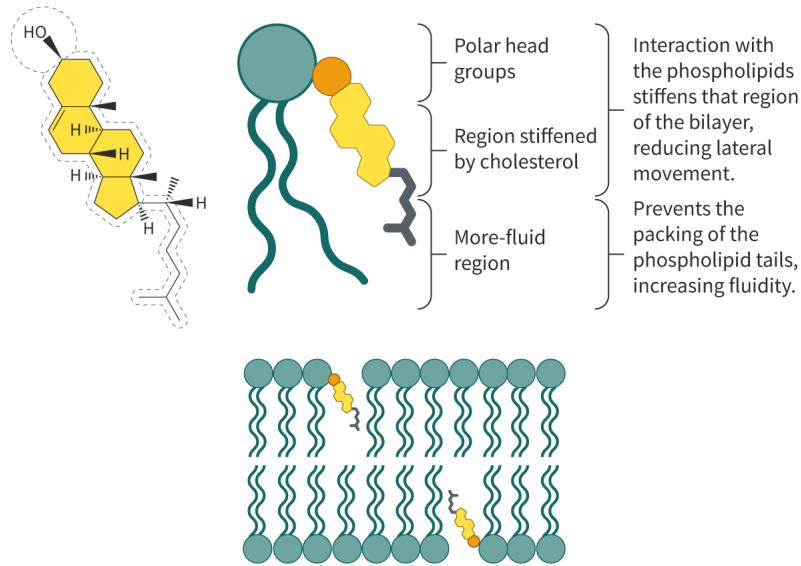


Figure 2. Influence of cholesterol on membrane fluidity.

More information for figure 2

The diagram illustrates how cholesterol affects membrane fluidity. It is divided into three sections. The first section on the left shows a structural formula of a cholesterol molecule with four hydrocarbon rings and a tail, labeled "HO" at the hydrophilic head. The second section in the center displays the interactions between cholesterol and phospholipids. A phospholipid is illustrated with a polar head group, a region stiffened by cholesterol, and a more-fluid region. Text labels indicate how cholesterol's interaction with phospholipids reduces lateral movement and increases fluidity by preventing the packing of phospholipid tails. The final section at the bottom illustrates a lipid bilayer model, where cholesterol molecules are nestled among phospholipids, influencing the structure and fluidity of the bilayer.

[Generated by AI]

The insertion of cholesterol molecules into the lipid bilayer works as follows:

- At low temperatures, the 'inserted' cholesterol prevents the fatty acid chains of the phospholipids from fitting closely together, preventing the tendency of the membranes to freeze.
- At high temperatures, cholesterol stabilises the membrane and reduces fluidity.
- It decreases the permeability of the membrane to ions and molecules.

Video 1 sums up the effect of fatty acid chains and cholesterol on membrane fluidity.



Cholesterol and the Cell Membrane | Cell Biology



Video 1. Membrane fluidity.

 Nature of Science

Aspect: Patterns and Trends

In 1925, Gorter and Grendel conducted experiments on red blood cells and realised that the monolayer had twice the surface area than the calculated value of the surface area of the plasma membrane. As a result, they suggested that the lipids were structured as a bilayer rather than a monolayer as was previously believed. This implied that the membrane had some fluidity, and Singer and Nicolson pursued this idea further. This is an illustration of how scientists analyse data, identify differences and draw inferences.

Membrane fluidity and formation of vesicles

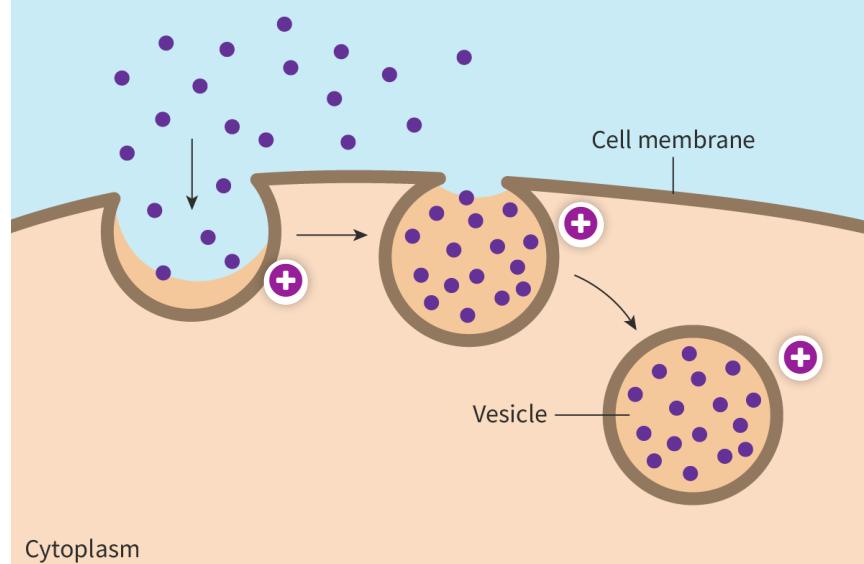
Often large amounts of material need to be transported in and out of the cell. The two bulk transport mechanisms utilised by cells are exocytosis and endocytosis. Both of these processes require energy and hence are active transport mechanisms.

Endocytosis

Endocytosis (endo – inside; cytosis – transport mechanism) is a bulk transport mechanism by which particles are moved into the cell. The cell membrane progressively invaginates and eventually engulfs the particles (to be taken in). The membrane then pinches off to form a vesicle with the ingested particles (**Interactive 1**).



Extracellular environment

**Interactive 1. Endocytosis.**

More information for interactive 1

The interactive diagram shows the process of endocytosis, a bulk transport mechanism where the cell engulfs external particles by forming vesicles. The interactive diagram consists of 3 clickable hotspots, each represented by a plus sign. These hotspots are named hotspot 1, hotspot 2, and hotspot 3. Clicking on these hotspots reveals information regarding the process of endocytosis at different stages.

The image is divided into two main sections, the top section is in light blue and is labelled "Extracellular environment". This is the space outside the cell. The bottom section is in peach colour and is labelled as "Cytoplasm", the inside the cell. A brown-coloured curved line separates these two regions and it is labelled as a "Cell membrane".

Small purple dots are scattered throughout the top left, in the extracellular environment. These small dots represent molecules or particles outside the cell that are being taken into the cell. On the left corner, the cell membrane (brown line) starts to bend inward, creating a cup-like shape to surround the particles. This step is called invagination. Hotspot 2 is located near this cup-like structure and clicking on it reveals the text "The membrane invaginates to form a cup-like structure that contains the target particles and other material."

Beside this cup-like structure, there is an arrow mark with its tip pointing towards the right. To the right of this arrow mark, the next step of endocytosis is shown, where the cup-like structure curves further, forming a circle with a small opening. There are more particles inside this circle when compared to the previous stage. Hotspot 1 is located near this step and clicking on it reveals the text "The ends of the membrane meet enclosing the extracellular material."

This is followed by another arrowmark, with its tip pointing downwards. In the last step, the membrane with particles, pinches off from the rest of the cell membrane, forming a circular membrane with particles (purple dots). This is labelled as a "vesicle". This vesicle is like a small bubble or pouch made from the same material as the cell membrane. The vesicle, now containing the purple particles, is fully inside the cell, floating in the cytoplasm. The contents can now be processed or transported within the cell. Hotspot 3 is located beside this vesicle and clicking on this hotspot reveals the text "The vesicle pinches off from the plasma membrane and the contents are processed by the cell."

The interactive image describes the process of endocytosis, including how the cell membrane engulfs external substances to form an internal vesicle. The viewers will be able to understand the role of the cell membrane, vesicle formation, and the transport of extracellular materials into the cytoplasm. This foundational concept supports learning about cellular transport mechanisms and membrane dynamics in biological systems.

The ingestion of large solid particles is called phagocytosis (cellular eating); the ingestion of liquids is called pinocytosis (cellular drinking).

Phagocytosis is seen in white blood cells (WBCs) and in unicellular organisms like Amoeba.

In the case of WBCs, projections of the membrane called pseudopodia gradually surround the foreign particles or microorganisms. Eventually the pseudopodia meet and engulf the particle resulting in a vesicle called a phagosome (food vacuole). The phagosome now fuses with a lysosome. The digestive enzymes of the lysosome



(see [section A2.2.4–6 \(/study/app/bio/sid-422-cid-755105/book/prokaryotic-and-eukaryotic-cells-id-43583/\)](#)), digest the particle, releasing nutrients. Within the phagosome, the particle is digested. **Video 2** shows phagocytosis of foreign particles by neutrophils, a type of WBC.



Video 2. Phagocytosis.

 More information for video 2

This video shows real-time phagocytosis, and perfectly illustrates phagocytosis in action.

Endocytosis is the process where cells engulf external particles or fluids by forming vesicles from the cell membrane. In the beginning of the video, the cell membrane on the right side of the screen, is seen extending pseudopodia (arm-like projections) to surround and engulf MRSA (highlighted in green). A cell membrane is seen invaginating to form a vesicle around the particle after which the particle is no longer visible. Later on, the membrane in the center, extends its pseudopodia to engulf another particle visible at the center of the screen.

During pinocytosis, the cell takes in small amounts of extracellular fluid. Unlike the large vesicles formed during phagocytosis, the vesicles formed are smaller.

Another type of endocytosis is receptor-mediated endocytosis (see [section B2.2.7–9 \(/study/app/bio/sid-422-cid-755105/book/membranes-and-protein-packaging-hl-id-44252/\)](#)).

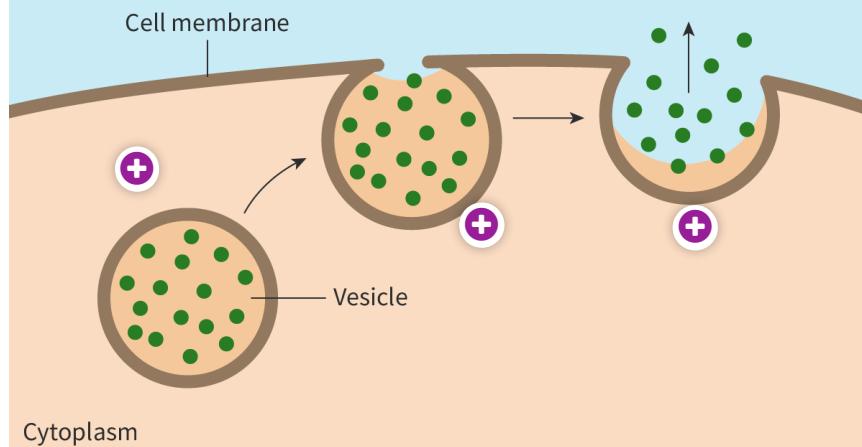
Exocytosis

Exocytosis (exo – external; cytosis – transport) is the reverse of endocytosis and involves the bulk transport of material to be secreted or excreted out of the cell. The material to be removed from the cell is enclosed in vesicles. The vesicles move to the plasma membrane and fuse with it, discharging its contents to the exterior ([Interactive 2](#)).

One example of exocytosis is the glycolipids produced by the endoplasmic reticulum and modified in the Golgi apparatus. The vesicles released by the Golgi apparatus fuse with the plasma membrane discharging their contents to the outside. Many other materials like enzymes, peptide hormones and antibodies are secreted by the cell via exocytosis.

Waste products and undigested food material are also excreted by the cell via exocytosis.

Extracellular environment

**Interactive 2. Exocytosis.**

More information for interactive 2

This interactive provides a detailed visual representation of the biological process known as **exocytosis**, which is the mechanism by which cells expel substances such as waste materials, enzymes, or signaling molecules into the extracellular environment.

The interactive diagram consists of 3 clickable hotspots, each represented by a plus sign. These hotspots are named hotspot 1, hotspot 2, and hotspot 3. Clicking on these hotspots reveals information regarding the process of exocytosis at different stages.

The image is divided into two main sections, the top section is in light blue and is labelled “Extracellular environment”. This is the space outside the cell. The bottom section is in peach colour and is labelled as “Cytoplasm”, the inside the cell. A brown-coloured curved line separates these two regions and it is labelled as a “Cell membrane”.

The process begins in the cytoplasm, where a **vesicle**—a small, membrane-bound sac—is shown containing several green dots representing particles. These particles symbolize the materials the cell needs to secrete or eliminate.

Hotspot 1 is located near this vesicle and clicking on it reveals the text “The vesicle containing the secretory or excretory material is formed.”

The vesicle, originating from an internal structure such as the Golgi apparatus (though not shown explicitly here), moves toward the **cell membrane** as indicated by the directional arrow. As it approaches the membrane, the vesicle becomes partially embedded in the membrane structure, initiating the fusion process. At the point of contact, the vesicle membrane merges seamlessly with the plasma membrane. This critical step, known as **membrane fusion**, allows the vesicle to form an open channel through which its contents can exit the cell. Hotspot 2 is located near this fusion area and clicking on it reveals the text “The vesicle moves to the plasma membrane and fuses with it.”

There is another arrow beside the area where the vesicle fuses with the plasma membrane. The tip of the arrow is pointing right, towards the last stage of exocytosis. The final stage is the release of the vesicle’s internal contents—represented by the green particles—into the extracellular space above the membrane. This release is depicted clearly with an upward and outward arrow, emphasizing the direction of movement. Hotspot 3 is located near this stage and clicking on it reveals the text “The contents of the vesicle are discharged to the outside.”

The interactive image effectively conveys the main stages of exocytosis through static visuals, arrows, and clearly marked steps. It serves as a helpful educational tool for understanding how cells maintain homeostasis and communicate with their surrounding environment by transporting materials outward through vesicular transport.

Endocytosis and exocytosis have opposite effects which are not restricted to the movement of materials. In exocytosis, as vesicles fuse with the plasma membrane, lipids and proteins are added. In endocytosis, the reverse happens during the invagination and pinching off of the plasma membrane to form vesicles.

Membrane fluidity plays an important role in the structural stability of vesicles during their formation and fusion in endocytosis and exocytosis.



Try creating a comic strip in the activity below to help with your understanding of bulk transport.

Overview
(/study/ap/
422-
cid-
755105/o

Activity

- **IB learner profile attribute:** Communicator
- **Approaches to learning:** Communication skills — Reflecting on the needs of the audience when creating engaging presentations
- **Time required to complete activity:** 30 minutes
- **Activity type:** Group activity

Your task

Create two comic strips that illustrate the mechanisms of bulk transport. The comic strips should show:

- how materials enter the cell through endocytosis (restricted to phagocytosis)
- how materials leave the cell through exocytosis.

Make sure that the comic strip is engaging yet accurate.

Instructions

- Form groups of four.
- Discuss and write the script.
- Decide the format. Your comic strip should have one row with four to six panels. Make sure that the width and height of the panels are the same.
- Plan what goes into each panel. Balance the text and images. Make sure that you do not put too much text.
- Draw the comic.
- Display in class.
- Peer-evaluate each other's comic strips using the rubric in **Table 1**.

Table 1. Evaluation rubric.



Student
view

Criteria	Good	Average	Needs improvement
Accuracy	The facts in the strip are accurate; there are no spelling errors.	Most of the facts are accurate, spelling errors restricted to 1—3.	A lot of facts are inaccurate with multiple spelling errors.
Presentation	The comic strip is neatly done, is easy to read and the information is well organised.	The comic strip is fairly neat, is fairly easy to read and the information is well organised.	The comic strip looks messy, the font is too small and the organisation is unclear to the reader.
Creativity	The comic strip shows a high degree of creativity and is visually appealing.	The comic strip has standard illustrations and is visually appealing.	The illustrations are not original and the visual appeal is low.
Elements	The strip has one row, with four to six panels; images and text are balanced.	The strip has one row, with four to six panels; the proportion of text is on the higher side.	The strip has fewer than four or more than six panels; the panels vary in height and width; there is too much text.

5 section questions ▾

B2. Form and function: Cells / B2.1 Membranes and membrane transport

More about transport mechanisms (HL)

B2.1.14: Gated ion channels in neurons (HL) B2.1.15: Sodium—potassium pumps (HL) B2.1.16: Indirect active transport (HL)

Section

Student... (0/0)

Feedback

Print (/study/app/bio/sid-422-cid-755105/book/more-about-transport-mechanisms-hl-id-44647/print/)

Assign ▾

Higher level (HL)

Learning outcomes

By the end of this section you should be able to:

- Describe the role of gated channels.
- Explain the mechanisms of direct active and indirect active transport.

A lot of places like airports or railway stations have automatic gates. The QR code of the ticket is scanned and access is either confirmed or denied. In other words, the gates either open or close. The gated channels in membranes work in similar ways. They respond to the inputs given by either opening or staying closed. In this section you will learn more about inputs that cause gated channels to open and close.



Gated ion channels in neurons

You may recall that ion channels (see [section B2.1.6–8 \(/study/app/bio/sid-422-cid-755105/book/facilitated-diffusion-and-active-transport-in-id-44644/\)](#)) are transmembrane proteins present on the cell membrane that form pores for the movement of ions across the membrane, down their concentration gradient. The physical structure of these channels is such that they demonstrate selectivity, meaning that only specific ions can pass through them.

These channels are usually gated, that is, they open or close in response to stimuli. Depending on the type of stimuli, they are classified as

- voltage-gated channels
- ligand-gated channels
- mechanically gated channels (which respond to mechanical cues such as sound waves and vibrations).

In this section, you will learn about two types of gated channels that are seen in neurons.

Resting membrane potential

One common example of voltage-gated ion channels is seen in nerve signalling.

Neurons are cells of the nervous system that transmit information in the form of electrical impulses. Even at rest (i.e. when the neuron is not conducting an impulse), there is a potential difference across the nerve cell membrane of -70 mV, which means that the inside of the neuron is more negatively charged than the extracellular environment. This is the resting membrane potential.

An electrochemical gradient exists across the nerve cell membrane with a higher concentration of potassium ions inside the cell. There is more about this in [section C2.2.1–4 \(/study/app/bio/sid-422-cid-755105/book/neurons-and-nerve-impulses-id-46646/\)](#).

Action potential and the role of the voltage-gated channels in neurons

Neurons are inherently excitable. A stimulus causes the generation of an electrical impulse. An impulse is a temporary reversal in the potential difference. This change in potential is due to the opening of voltage-gated sodium channels and voltage-gated potassium channels. Both these channels are highly specific and remain closed during the resting state. Let us learn how these channels work.

A stimulus causes the ‘activation gate’ of the voltage-gated sodium channels to open first. Sodium ions diffuse rapidly into the neuron. The entry of the sodium ions causes the interior of the neuron to be more positively charged than the exterior (depolarisation), generating an action potential. The action potential travels down the nerve fibre (see [section C2.2.1–4 \(/study/app/bio/sid-422-cid-755105/book/neurons-and-nerve-impulses-id-46646/\)](#)).

Almost immediately, the voltage-gated sodium channels close and the voltage-gated potassium channels open. Potassium ions diffuse out of the neuron down their concentration gradient and the interior of the neuron becomes less positive (repolarisation). Eventually, the potassium channels close. The resting membrane potential is now re-established with the help of the sodium–potassium pump, as described later in this section.

It is important to note that the gated channels would open or close only when the voltage reaches a certain minimum value called the threshold value. In addition, voltage-gated channels undergo channel inactivation where an inactivation particle blocks the channel pore (**Figure 1**). During this time, the channels do not open at all – it is like a padlock on a gate!



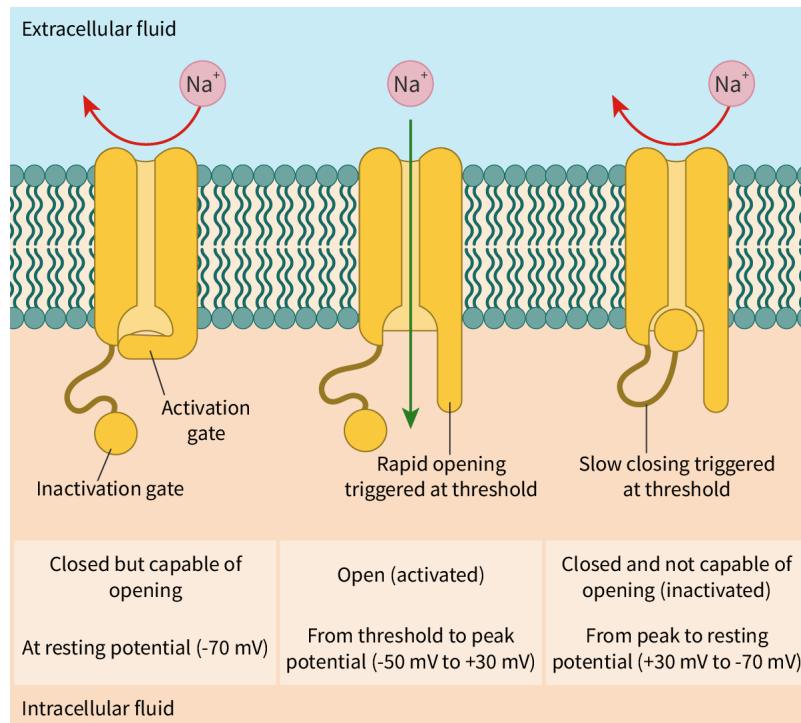


Figure 1. Opening and closing of the voltage-gated sodium channel.

More information for figure 1

The diagram depicts the voltage-gated sodium channel across a cell membrane, illustrating its different states. On the left, the channel is closed but capable of opening, represented by a closed channel with an activation gate labeled "Inactivation gate". This state is at resting potential, indicated as -70 mV. In the middle, the channel is open and activated, showing an open passage for sodium ions (Na⁺) with an arrow marked "Rapid opening triggered at threshold". This state occurs from threshold to peak potential with a range from -50 mV to +30 mV. On the right, the channel is closed and not capable of opening (inactivated), indicated by a closed channel with internal blocking. This state occurs from peak to resting potential from +30 mV to -70 mV. Above and below the channel are labels "Extracellular fluid" and "Intracellular fluid," representing the outer and inner cellular environments, respectively.

[Generated by AI]

Nicotinic acetylcholine receptor: a ligand-gated channel

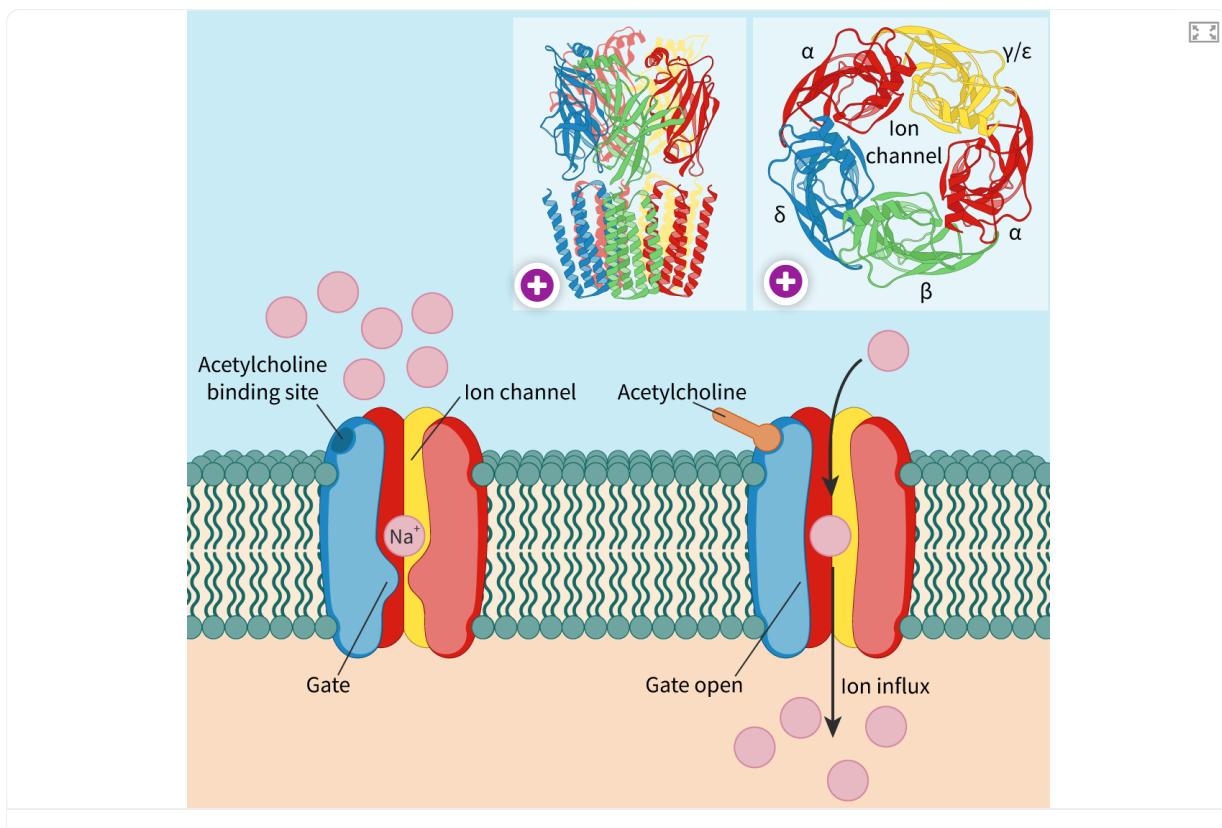
Ligand-gated channels are ion channels that open when a ligand binds to the transmembrane protein (of the ion channel). When the ligand is a neurotransmitter, the ion channel is called a neurotransmitter-gated ion channel.

Acetylcholine is an excitatory neurotransmitter. Nicotinic acetylcholine receptors (nAChR) are ligand-gated ion channels present at skeletal neuromuscular junctions (**Interactive 1**). The binding of acetylcholine molecules results in a conformational change that opens the channel. Sodium ions now diffuse down their concentration gradient resulting in the interior of the cell becoming more positive (depolarisation). Within a millisecond, the enzyme cholinesterase breaks down acetylcholine, leading to closure of the ion channels.

Nicotine is a component of cigarettes. Like acetylcholine, nicotine can activate these channels, hence the term 'nicotinic' acetylcholine receptors.

Depolarisation is followed by opening of voltage-gated potassium channels and exit of potassium ions resulting in repolarisation. Soon the voltage-gated potassium channels close and resting membrane potential is restored.

Home
Overview
(/study/app/
422-
cid-
755105/o)



Interactive 1. Nicotinic Acetylcholine Receptor.

[More information for interactive 1](#)

An interactive illustration explains the function of ligand-gated ion channels, specifically nicotinic acetylcholine receptors (nAChRs), at the neuromuscular junction. Users interact with 3D ribbon models and extracellular views of the receptor to understand how neurotransmitters like acetylcholine (and also nicotine) bind and activate the channel.

The interactive demonstrates the step-by-step mechanism from ligand binding to ion influx and membrane depolarization.

Two panels are present on the top.

1. A 3D ribbon model of the acetylcholine receptor inside view. A selectable interactive hotspot displays the following: An example of a ligand-gated ion channel. Ribbon model of nicotine acetylcholine receptor viewed from the side. The receptor is composed of five sub-units: two alpha, one beta, one delta, and either a gamma or epsilon.
2. The top view shows the receptor from above, allowing users to visualize the central aqueous pore where sodium ions (Na^+) pass through upon activation. A selectable interactive hotspot displays the following: Extracellular (top) view of acetylcholine receptor. Each subunit is labeled to help understand the receptor's structural organization.

Step-by-step mechanism:

1. Ligand Binding:

Acetylcholine molecule binds to specific sites on the α subunits, initiating channel opening.

2. Ion Channel Activation:

Upon ligand binding, the gate of the ion channel opens, allowing Na^+ ions to flow through the pore and into the cell.

3. Ion Influx and Membrane Depolarization:

The influx of sodium ions leads to membrane depolarization, a key process required for muscle contraction.

This interactivity helps users understand how acetylcholine functions as a neurotransmitter at ligand-gated channels and explains the mechanism of channel activation through ligand binding.



Aspect: Evidence



In science, the evidence collected by direct observation or experimentation is used to support claims. The functioning of gated channels in response to changes in voltage or binding of different ligands including medicines and toxins are ongoing areas of research. The evidence collected would help scientists support or refute current hypotheses. The evidence could also be used by scientists to understand how the ion channels function and how their behaviour can be manipulated for treating diseases like epilepsy or chronic pain.

Direct active transport: the sodium—potassium pump

The sodium—potassium (Na^+/K^+) pump is found in the cell membranes of all animal cells and involves active transport. The Na^+/K^+ pump is an enzyme that generates energy by the breakdown (hydrolysis) of ATP. For this reason, the Na^+/K^+ pump is called Na^+/K^+ ATPase. The energy released in the process is used to drive the transport of sodium and potassium ions against their concentration gradient.

Most animal cells – including neurons – have a high intracellular concentration of K^+ and a low intracellular concentration of Na^+ , creating an electrochemical gradient. This asymmetric distribution of ions is in part due to the Na^+/K^+ pump, with the active transport of K^+ into the cells and Na^+ out of the cells.

Working of the Na^+/K^+ pump

The Na^+/K^+ pumps are transmembrane pumps with three binding sites for sodium and two for potassium (Figure 2).

- Initially, the Na^+/K^+ pump is open to the inside of the cell in a way that the sodium ions bind to all three of its binding sites.
- The binding of sodium ions triggers the hydrolysis of ATP to ADP and a phosphate group. The latter attaches to the pump resulting in a conformational change. The pump now opens to the exterior releasing the sodium ions.
- At the same time, potassium ions attach to both binding sites. This causes the phosphate group to detach from the pump.
- The pump undergoes a conformational change to regain its original form and once again opens to the interior of the cell.

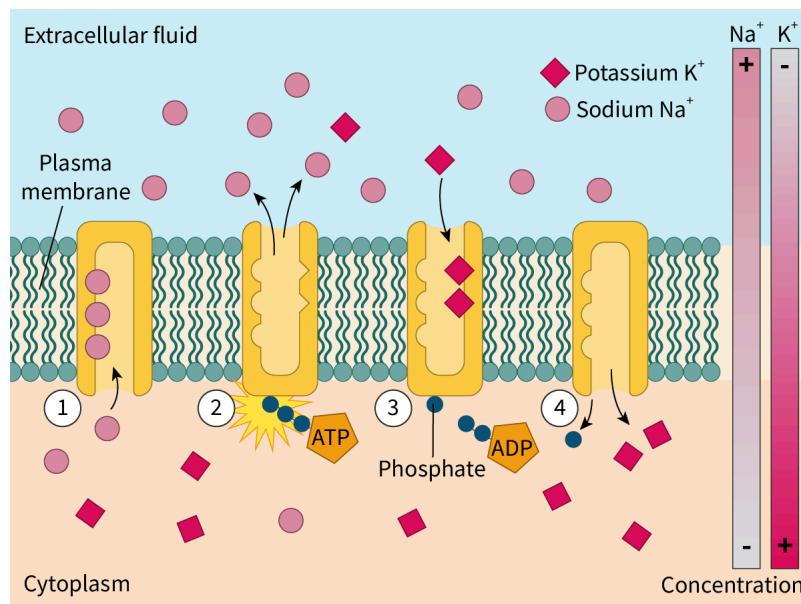


Figure 2. The sodium—potassium pump in action.

[More information for figure 2](#)

The diagram illustrates the function of the sodium-potassium pump across the plasma membrane. It shows multiple steps in the process of moving sodium (Na^+) and potassium (K^+) ions across the membrane.



1. In the extracellular fluid, sodium ions bind to the pump located on the plasma membrane. The pump has a specific capacity to bind three sodium ions from the inside of the cell.
2. ATP is hydrolyzed, transferring a phosphate group to the pump, causing the pump to change its shape and release the sodium ions into the extracellular fluid.
3. The new shape allows the binding of two potassium ions from the extracellular fluid.
4. Phosphate is released, allowing the pump to revert to its original shape, bringing in the potassium ions and releasing them into the cytoplasm.

The diagram also includes labels indicating the extracellular fluid and cytoplasm, with a key for ion symbols: squares represent potassium ions and circles represent sodium ions. Additionally, a concentration bar shows a gradient from low to high concentration, matching the movement of ions.

[Generated by AI]

Thus, for every molecule of ATP hydrolysed, three sodium ions are pumped out and two potassium ions are pumped in. This builds a high concentration of K^+ inside the cells. The Na^+/K^+ pump thus helps to establish and maintain the voltage across the membrane. It thereby plays an important role in re-establishing the membrane potential after the passage of a nerve impulse.

Indirect active transport

The Na^+/K^+ pump uses ATP as an energy source and is hence considered as direct active transport.

Indirect active transport is another mechanism. Here the source of energy is not ATP. The mechanism involves the transport of two solutes (ions or molecules); however, one solute is transported *down* its concentration gradient while the other is transported *against* its concentration gradient. The favourable movement (down the concentration gradient) is thereby coupled with an unfavourable movement (against the concentration gradient) and drives the latter.

- Sodium ions bind to binding sites on the outer surface of the cotransporter.
- Simultaneously, a molecule of glucose also binds to its binding site on the cotransporter.
- This results in a conformational change that transports both the sodium ions and the glucose molecule to the inside of the cell.

The sodium gradient is maintained by the Na^+/K^+ pump which transports the sodium ions out of the cell.

Figure 3 illustrates this process.

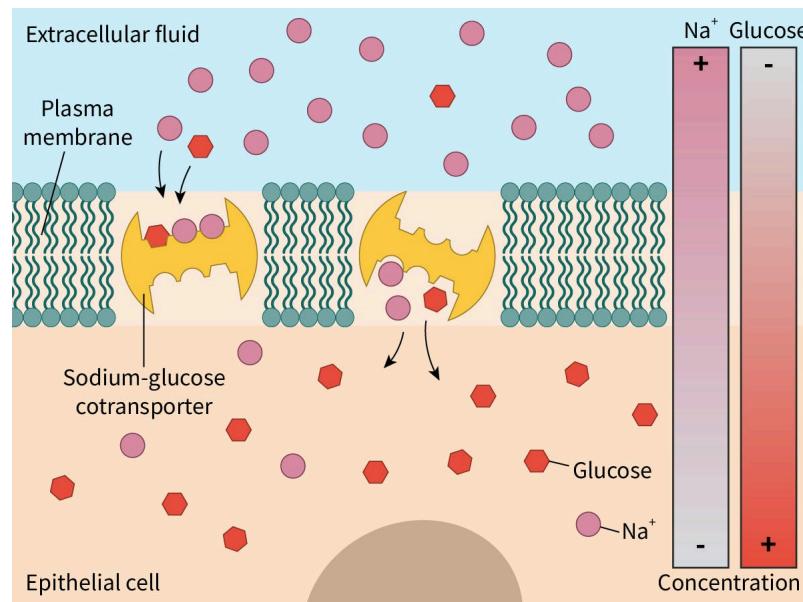


Figure 3. Indirect active transport.



More information for figure 3

The diagram illustrates the process of sodium-glucose cotransport across a plasma membrane. It shows extracellular fluid and epithelial cells at the top and bottom of the image. In between, a cellular membrane with embedded sodium-glucose cotransporters is visible. Sodium ions (Na^+) and glucose molecules are shown moving from the extracellular fluid through the cotransporter into the epithelial cell. There is also a gradient illustration on the right side exhibiting concentration levels with Na^+ on one side and glucose on the other, indicating positive and negative concentration gradients. Key components are labeled such as 'Sodium-glucose cotransporter,' 'Plasma membrane,' 'Extracellular fluid,' and 'Epithelial cell.'

[Generated by AI]

Let us have a look at a couple of examples.

Soon after digestion, nutrient molecules like glucose or amino acids need to be transported from the intestinal lumen to the epithelial cells lining the small intestine, against their concentration gradient. This is an energy-requiring or endergonic process. The energy for this comes from the simultaneous transport of sodium ions, which is an energy-releasing or exergonic process as the ions are transported down their electrochemical gradient.

Indirect active transport also comes into play in the reabsorption of glucose by the cells of the nephron. Our kidneys filter blood. As the blood is filtered, along with the urea and waste material, large amounts of glucose and other useful substances are removed. The glucose molecules in the renal filtrate are reabsorbed (see [section D3.3.7–8 \(/study/app/bio/sid-422-cid-755105/book/excretion-hl-id-46231/\)](#)) with the help of the sodium-dependent glucose cotransporters present on the kidney epithelial cells, preventing the loss of glucose.

Video 1 compares direct active transport and indirect active transport with an easy analogy. (Note that the video uses the term ‘primary’ for ‘direct’ active transport and ‘secondary’ for ‘indirect’ active transport.)

Primary Active Transport vs Secondary Active transport



Video 1. Direct active transport and indirect active transport.

🔗 Making connections

You may have learned in Physics that kinetic energy is the energy associated with objects in motion whereas potential energy is the energy an object has due to its relative position. What role does potential and kinetic energy play in the movement of solutes in indirect active transport?



Try this activity to compare methods of direct with indirect active transport.

 **Activity**

- **IB learner profile attribute:** Knowledgeable
- **Approaches to learning:** Thinking skills — Combining different ideas in order to create new understandings
- **Time required to complete activity:** 20 minutes
- **Activity type:** Individual activity

Read and answer the questions given below. Draw rough sketches to illustrate the points wherever needed.

1. How does the resting membrane potential differ from the action potential?
2. Correlate between the membrane potential and opening/closing of voltage-gated sodium and potassium channels.
3. How are voltage-gated channels similar to nicotinic acetylcholine receptors? How are they different?
4. Compare direct and indirect active transport using the criteria given in **Table 1**.

Table 1. Evaluation criteria.

Criteria	Direct active transport	Indirect active transport
Purpose of the mechanism		
Protein pump		
Ions/molecules transported		
Source of energy		
One example		

5 section questions ▾

B2. Form and function: Cells / B2.1 Membranes and membrane transport

CAMs and cell adhesion (HL)

B2.1.17: Adhesion of cells to form tissues (HL)

Section

Student... (0/0) 

 Print

(/study/app/bio/sid-422-cid-755105/book/cams-and-cell-adhesion-hl-id-44648/print/)

Assign

Higher level (HL)

Learning outcomes

By the end of this section you should be able to:

- State the role of cell-adhesion molecules.



- Identify the different types of cell junctions.

Biological organisation is amazing. Cells come together to form tissues and tissues form organs. How do these cells adhere together to form tissues or organs? Do all cells stick together in a similar way?

Cell-adhesion molecules or CAMs

At a biological level, adhesion is the binding of cells with each other to form tissues.

Cell-adhesion molecules or CAMs play a crucial role in cell adhesion. These glycoproteins mediate the binding of cells with other adjacent cells or with the extracellular matrix. The different forms of CAM include cadherins, integrins, selectins and the immunoglobulin super family.

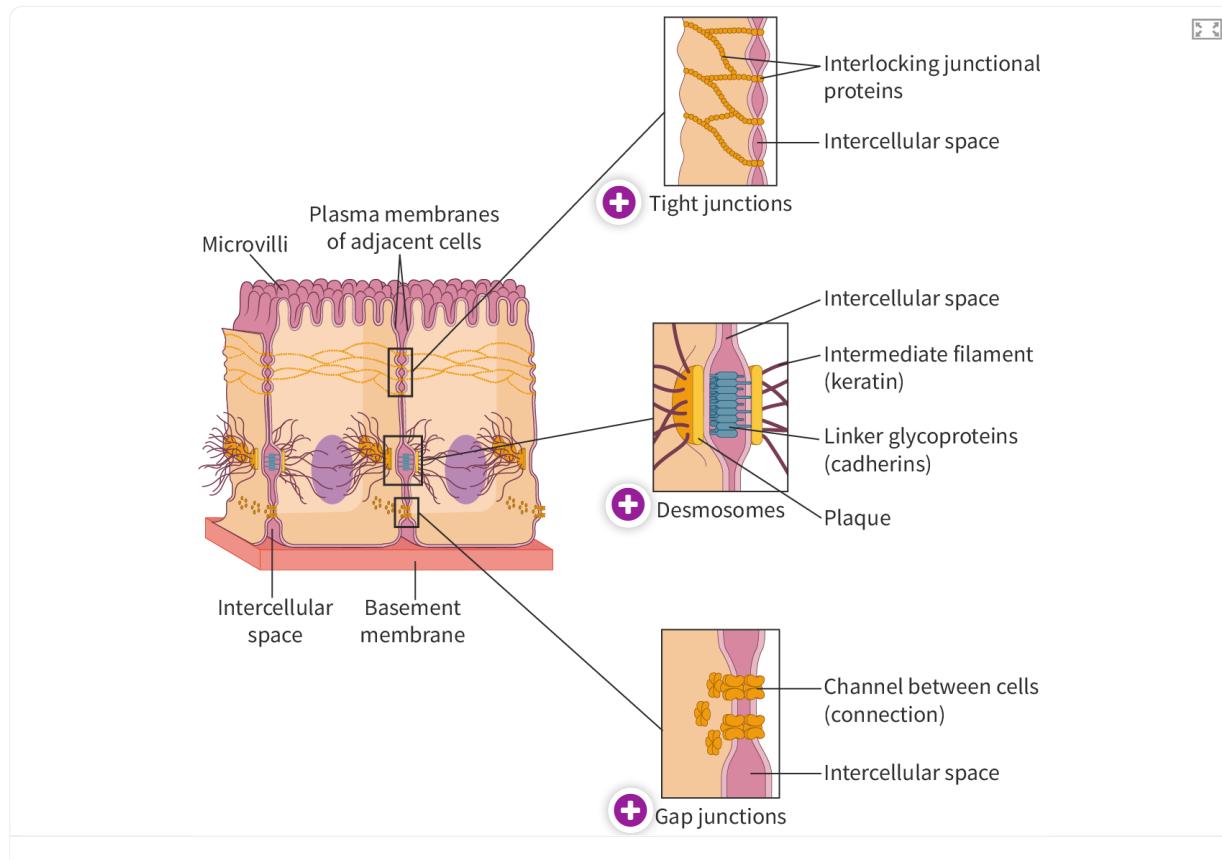
Cell junctions

Cell junctions connect cells to each other allowing intracellular transport and communication. They play important roles in cell proliferation, cell migration and prevent unregulated movement of materials between cells. CAMs are essential for the formation of cell junctions.

The main types of cell junctions, in animals, are listed below and are shown in **Interactive 1**.

- Adhesive junctions (including adherens junctions and desmosomes) — are present in epithelial cells and cardiac cells. They facilitate cell—cell adhesion in tissues to ensure structural stability and allow the cells to withstand mechanical stress. For this reason, they are often called anchoring junctions.
- Tight junctions — are present in epithelial cells; they form a tight seal between two neighbouring cells and act as occluding junctions. This barrier prevents the unregulated movement of molecules across the barrier.
- Gap junctions — are found in several cell types throughout the body. They are intracellular channels physically connecting neighbouring cells for the movement of molecules. As they help in the cell—cell transfer of small molecules, they are often called communicating junctions.

The type of CAMs used depends on the types of cell junctions.



Interactive 1. Types of Cell Junctions.



Overview
(/study/ap/
422-
cid-
755105/o)

This illustration presents a comprehensive cross-section of epithelial cells, highlighting the three primary types of cell junctions that link neighbouring cells: tight junctions, desmosomes, and gap junctions. These junctions are essential for maintaining tissue structure, facilitating communication and transport between cells, and regulating the movement of substances in and out of the cells.

The cross-sectional view of epithelial cells is located on the left-hand side of the diagram. The epithelial cells look column-shaped and are standing vertically. The very top of the cells are covered with short, dense, finger-like projections called microvilli. These microvilli look like a tightly packed brush or fringe and they enhance the surface area available for absorption. The cell membrane forms the outer boundary of the cells and runs down the sides, closely hugging the neighbouring cells. The membrane forms junctions with the adjacent cell at three key points (tight junction, desmosome, gap junction), which are represented as highlighted squares along the right side of the cell.

Deeper inside the cells, there is a round, purple nucleus, located roughly at the centre. The area around the nucleus and throughout the cell is filled with cytoplasm—a gel-like substance that contains various organelles. The bottom of the cell rests on a flat, reddish-pink basement membrane. Above this basement membrane, the space between two cells is labelled as “Intercellular space”.

The three principal types of cell junctions in the epithelial cells are highlighted on the right-hand side. These cell junctions include Tight junctions, Desmosomes and Gap junctions. Each of these cell junctions consists of a clickable hotspot represented by a plus sign. Clicking on these hotspots reveals additional information about the cell junctions.

Read below to learn about each cell junction and the information in the hotspot:

1. Tight Junctions: Positioned near the upper part of adjacent epithelial cells, the zoomed-in section on the right reveals the cell membranes of two cells touching closely with interlocking junctional proteins that create a tight seal. These proteins are closely arranged to eliminate gaps between cells. Hotspot 1 for tight junctions reveals: “Tight junctions are impermeable; they prevent molecules from passing through the intercellular space.”

They function similarly to a zipper, sealing the spaces between cells to prevent the leakage of water, ions, and other substances.

2. Desmosomes (Adhesive Junctions): It is located in the middle part of adjacent epithelial cells and the zoomed-in view is provided on the mid-right portion of the image. The zoomed-in view illustrates dense plaque on the inner side of each cell membrane that connects to intermediate filaments (keratin) which extend throughout the cell. Between the two cells, linker glycoproteins (cadherins) connect like Velcro to hold the cells together while allowing some flexibility. A small intercellular space is visible. Hotspot 2 for desmosomes reveals: “Desmosomes are adhesive junctions; they bind adjacent cells together and help form an internal tension-reducing network of fibres.”

Desmosomes are vital for providing mechanical strength to tissues found in the skin and heart muscle.

3. Gap Junctions: Located on the lowermost part of the cell membranes. These appear as channels that connect two neighbouring cells, allowing direct transfer of small molecules and ions. The zoomed-in view on the bottom right side shows a channel between cells that forms a tunnel-like structure across the intercellular space. Hotspot 3 in the gap junction reveals: “Gap junctions allow molecules to pass from one cell to another for intercellular communication.”

Gap junctions are important for cell-to-cell communication, especially in heart and smooth muscle cells where electrical signals need to pass quickly. They form small channels between neighbouring cells that allow ions, sugars, and other small molecules to move directly from one cell to another.

Understanding these cell junctions is essential for learning how tissues function in the body. This diagram helps illustrate tight junctions responsible for sealing, desmosomes responsible for support, and gap junctions responsible for communication. These junctions work together to maintain tissue integrity, allow cell signalling, and control substance flow in multicellular organisms.

Video 1 gives you an overview of the different types of junctions seen in our body. The term anchoring junctions instead of adhesive junctions is used in the video. Remember, you are not expected to have detailed knowledge of the junctions.

Cell Junctions



Student
view

Video 1. Overview of cell junctions.

⌚ Making connections

Although in this subtopic CAM refers to 'cell-adhesion molecule', the acronym is also used for 'crassulacean acid metabolism', a specialised form of photosynthesis. The CAM pathway evolved as a mechanism to minimise the loss of water and is seen in plants living in arid (dry) regions.

Try the activity below in pairs to help with your understanding of CAMs.

⚙️ Activity

- **IB learner profile attribute:** Knowledgeable
- **Approaches to learning:** Thinking skills — Applying key ideas and facts in new contexts
- **Time required to complete activity:** 15 minutes
- **Activity type:** Pair activity

Below are some descriptions of medical conditions/diseases associated with the impaired functioning of cell junctions. Use Think-Pair-Share to identify the junction involved.

1. The blood—brain barrier is a network of capillaries that prevents harmful substances from reaching the brain. The endothelial cells of the capillaries that form the blood—brain barrier are wedged tightly together by _____ junctions to prevent the unwanted and unregulated movement of molecules from the blood into the brain.
2. In a laboratory, when a group of cardiac muscle cells were treated with drug X, it led to a disruption of _____ junctions which in turn prevented the transmission of electrical impulses through the cardiac muscle cells.
3. Junctional Epidermolysis Bullosa is a disorder that results in development of sores and blisters on the application of minimal pressure on the skin. This is because the _____ are not functioning due to which the skin and other epithelial tissues are unable to withstand the everyday wear and tear.
4. A leaky gut is caused when harmful substances from the gut enter your bloodstream due to a decrease in the _____ junction function.

5 section questions ▾

B2. Form and function: Cells / B2.1 Membranes and membrane transport

Summary and key terms

Section

Student... (0/0)

➡ Feedback

🖨 Print

(/study/app/bio/sid-422-cid-755105/book/summary-and-key-terms-id-44650/print/)

Assign



- Biological membranes are formed of lipids, proteins and small amounts of cholesterol. The proteins in the lipid layer are either integral proteins or peripheral proteins.
- Amphipathic lipids like phospholipids spontaneously organise themselves in water to form a sheet-like bilayer. The continuous hydrophobic core acts as a barrier. The entry of molecules depends on the size of the molecule and their nature – whether polar or non-polar.

- The movement of molecules includes passive transport mechanisms like simple diffusion, and facilitated diffusion and active transport using ATP. Aquaporins are channel proteins that play an important role in the diffusion of water. Facilitated diffusion and active transport determine the selective permeability of the membrane.
- Glycoproteins and glycolipids are carbohydrate chains attached to the proteins and lipids of the cell membrane that play an important role in cell adhesion and cell recognition.
- The fluid mosaic model proposed by Singer and Nicolson depicts the structure of the cell membrane.

Higher level (HL)

- The relative proportions of unsaturated and saturated fatty acids in the lipid bilayer, as well as the presence of cholesterol, influence membrane fluidity.
- Membrane fluidity plays an important role in bulk transport mechanisms like endocytosis and exocytosis.
- Gated ion channels are passive transport mechanisms and include voltage-gated and ligand-gated channels.
- Sodium-potassium pumps are an example of direct active transport whereas sodium-dependent glucose cotransporters are an example of indirect active transport.
- Cell junctions include adhesive junctions, tight junctions and gap junctions. Cell-adhesion molecules or CAMs include cadherins, selectins, integrins and immunoglobulins.

Key terms

Review these key terms. Do you know them all? Fill in as many gaps as you can using the terms in this list.

- Due to their amphipathic nature, phospholipids spontaneously reorganise themselves in water to form lipid
- Membrane proteins are of two types: _____ are embedded in the lipid bilayer and are difficult to extract whereas _____ are easier to extract. An example of integral proteins are specialised channel proteins called _____ that ensure the rapid diffusion of water across the plasma membrane.
- When the diffusion of molecules across biological membranes is aided by specialised transport proteins, it is called _____. The proteins could be _____ pores for the molecules to pass through or _____ proteins that undergo conformational changes. On the other hand, movement of molecules from a region of their lower concentration to a region of their higher concentration is called _____
- The covalent bonding of carbohydrates to lipids results in a class of molecules called _____. Similarly, _____ are formed when carbohydrates bond with proteins.
- The _____ of membrane structure states that the membrane is a mosaic of proteins within a fluid lipid bilayer.

Check

Higher level (HL)

Interactive 1. Membranes and Membrane Transport.

Key terms

Review these key terms. Do you know them all? Fill in as many gaps as you can using the terms in this list.

1. In cell membranes of cold-blooded animals, the proportion of fatty acids is higher than that of fatty acids to ensure membrane fluidity.
 2. acts as a modulator contributing both to membrane fluidity at lower temperatures and stability at higher temperatures.
 3. Bulk transport mechanisms could include or the intake of materials into the cell, and or the expulsion of materials from the cell. The former includes both or 'cellular eating' and or 'cellular drinking'.
 4. ion channels are activated by changes in the membrane potential.
ion channels are activated by the binding of molecules like neurotransmitters.
- Nicotinic acetylcholine receptors are channels that are activated by the binding of acetylcholine or
5. Cell junctions in animal cells include that allow cells to withstand mechanical stress, that act as barriers and permit the movement of molecules between adjacent cells. that play an important role in the formation of cell junctions.

Check

Interactive 2. Structure of Cell Membrane.

What you should know

After studying this subtopic you should be able to:

- Describe the formation of sheet-like bilayers in water by amphipathic lipids.
- Explain the reasons behind the selective permeability of the lipid bilayer.
- Discuss the movement of molecules by diffusion across the lipid bilayer.
- Identify integral and peripheral proteins.
- Discuss the role of aquaporins in transporting water.
- Describe the structure and role of channel proteins.
- Explain the importance of pump proteins in active transport.
- Explain the role of facilitated diffusion and active transport in the selective permeability of membranes.
- Describe glycoproteins and glycolipids with respect to their structure and function.
- Draw the fluid mosaic model of membrane structure.

Higher level (HL)

- Describe the role of lipids in membrane fluidity.
- Discuss the role of cholesterol in membrane fluidity.
- Differentiate between exocytosis and endocytosis.
- Describe the role of gated channels.
- Explain the mechanisms of direct active and indirect active transport.
- State the role of cell-adhesion molecules.
- Identify the different types of cell junctions.

B2. Form and function: Cells / B2.1 Membranes and membrane transport

Investigation

- **IB learner profile attribute:** Inquirers
- **Approaches to learning:** Thinking skills – Applying key ideas and facts in new contexts
- **Tool 2:** Technology
- **Inquiry 1:** Exploring and designing
- **Inquiry 3:** Concluding and evaluating
- **Time required to complete activity:** 120 minutes
- **Activity type:** Pair activity

New scientific evidence gathered through observation, experimentation and advances in technology often leads to new models coming in. One such example are the multiple models of membrane structure that were proposed to explain the assembly of biological membranes and their permeability.



Student
view



Your task

Overview
 (/study/app/bio/sid-422-cid-755105/o)
 The fluid mosaic model was proposed by Singer and Nicolson in 1972. Although the model still stands true, recent studies (and information not available 40 years ago) have led to 'updation' of this model. Read the research paper given [here](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7159824/#:~:text=An%20updated%20Fluid%2DMosaic%20Membrane,in) (<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7159824/#:~:text=An%20updated%20Fluid%2DMosaic%20Membrane,in>) to understand the evolution of the fluid mosaic model.

Summarise your understanding by answering the following questions.

1. It was proposed that the model should include a new class of membrane-associated proteins. What was the role of these proteins? Why were they called membrane-associated and not simply membrane proteins?
2. The paper talks about 'lipid rafts'. How does this differ from your understanding of arrangement of lipids in the fluid mosaic model?
3. These 'rafts' are garnering a lot of interest in their role in membrane function. Explain.
4. In the proposed model, the hydrophobic-matching principle comes into play. Explain the role of hydrophobic matching in membrane stability.

Once you find the answers to these questions, find a partner and discuss. Conclude by linking what you have read to the guiding questions.

B2. Form and function: Cells / B2.1 Membranes and membrane transport

Reflection

Section

Student...

(0/0)

Feedback

Print

(/study/app/bio/sid-422-cid-755105/book/reflection-id-46873/print/)

Assign

Teacher instructions

The goal of this section is to encourage students to reflect on their learning and conceptual understanding of the subject at the end of this subtopic. It asks them to go back to the guiding questions posed at the start of the subtopic and assess how confident they now are in answering them. What have they learned, and what outstanding questions do they have? Are they able to see the bigger picture and the connections between the different topics?

Students can submit their reflections to you by clicking on 'Submit'. You will then see their answers in the 'Insights' part of the Kognity platform.

Reflection

Now that you've completed this subtopic, let's come back to the guiding question introduced in [The big picture](#) ([/study/app/bio/sid-422-cid-755105/book/the-big-picture-id-43205/](#)).

- How do molecules of lipid and protein assemble into biological membranes?
- What determines whether a substance can pass through a biological membrane?

With these questions in mind, take a moment to reflect on your learning so far and type your reflections into the space provided.

You can use the following questions to guide you:



Overview
(/study/app/
422-
cid-
755105/o

- What main points have you learned from this subtopic?
- Is anything unclear? What questions do you still have?
- How confident do you feel in answering the guiding questions?
- What connections do you see between this subtopic and other parts of the course?

⚠ Once you submit your response, you won't be able to edit it.

0/2000

Rate subtopic B2.1 Membranes and membrane transport

Help us improve the content and user experience.



Student
view