لجان الدُّفعات

PHYSIOLOGY

MORPHINE ACADEMY

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FACULTY OF PHARMACEUTICAL SCIENCES
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LECTURE 2, PART (2): TRANSPORT PROCESSES OF SOLUTES AND WATER

Membrane permeability:

- The permeability of the plasma membrane to different substances varies.

- **The hydrophobic interior of the plasma membrane allows nonpolar molecules** to rapidly pass through, but prevents passage of ions and large, uncharged polar molecules.

- Because **water and urea** are small polar molecules that have no overall charge, they can **move from one gap** (small gaps appear in the hydrophobic environment of the membrane's interior) to another until they have crossed the membrane without any assistance.

- **Transmembrane proteins that act as channels and carriers** (very selective) increase the plasma membrane's permeability to a variety of **ions and uncharged polar molecules** (need assistance).

Gradients across the Plasma Membrane:

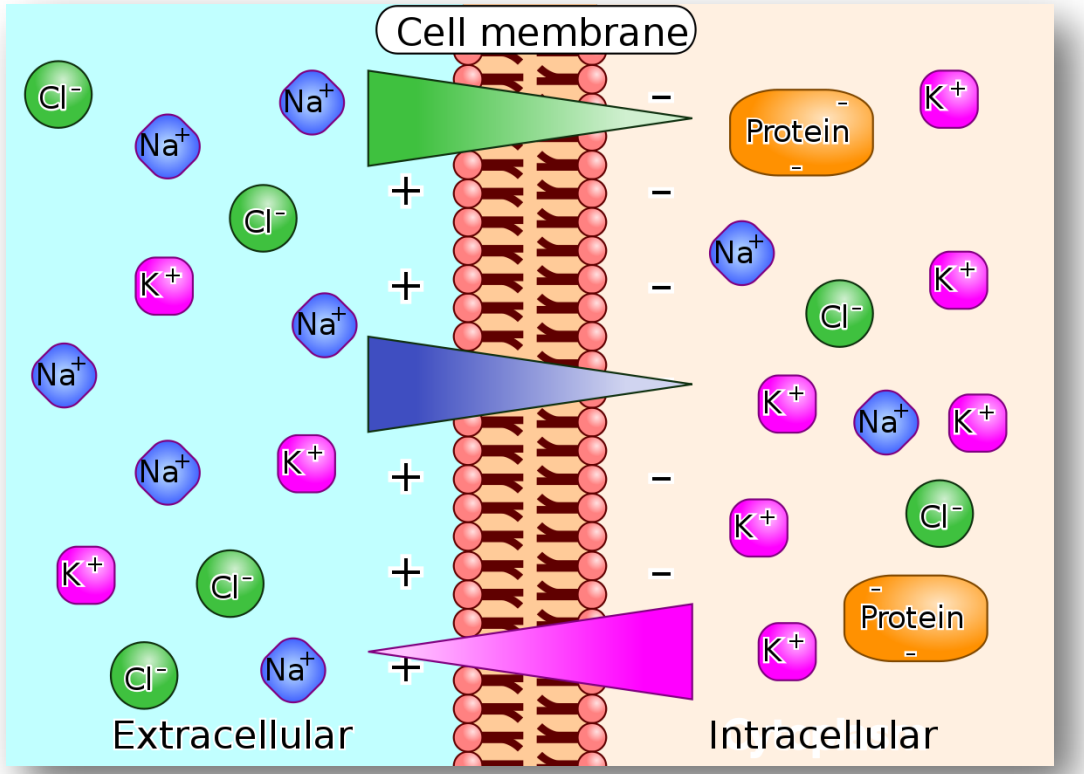
- A ***concentration gradient*** is a difference in the concentration of a chemical from one place to another, such as from the inside to the outside of the plasma membrane. A substance will move "downhill," from where it is more concentrated to where it is less concentrated, to reach equilibrium.

- The plasma membrane also creates a difference in the distribution of positively and negatively charged ions between the two sides of the plasma membrane.

Gradients across the Plasma Membrane:

- The difference in electrical charges between two regions constitutes an ***electrical gradient***. This termed **the membrane potential**. A positively charged substance will tend to move toward a negatively charged area, and a negatively charged substance will tend to move toward a positively charged area.

- The combined influence of the concentration gradient and the electrical gradient on movement of a particular ion is referred to as its ***electrochemical gradient***.



TRANSPORT ACROSS THE PLASMA MEMBRANE

- Substances generally move across cellular membranes via **transport processes** that can be classified as passive or active, depending on whether they require cellular energy.

- In **passive processes**, a substance moves down its concentration or electrical gradient to cross the membrane using only its own kinetic energy (energy of motion).

- In **active processes**, cellular energy (in the form of adenosine triphosphate (ATP)) is used to drive the substance "uphill" against its concentration or electrical gradient.

TRANSPORT ACROSS THE PLASMA MEMBRANE

النقل بالحويصلات

في طريقة ثانية لدخول وخروج المواد من وإلى الخلايا هاي عملية ذكية جدًا، حيث بتستخدم حويصلات صغيرة كروية vesicles

Another way that some substances may enter and leave cells is an **active process** in which tiny, spherical membrane sacs referred to as **vesicles** are used. Examples include **endocytosis**, in which vesicles detach from the plasma membrane while bringing materials into a cell, and **exocytosis**, the merging of vesicles with the plasma membrane to release materials from the cell.

من الغشاء البلازمي.

تنفصل

تندمج

Endocy	Exocy
بالعة	اخراج خلوي
تنفصل الحويصلات من الغشاء البلازمي لتدخل مواد إلى داخل الخلية.	تنفصل الحويصلات من الغشاء البلازمي لتخرج المواد خارج الخلية

PASSIVE PROCESSES

- **Diffusion** is a passive process in which the random mixing of particles (solutes, the dissolved substances, and the solvent) in a solution occurs because of the particles' kinetic energy.

- If a particular solute is present in high concentration in one area of a solution and in low concentration in another area, solute molecules will diffuse toward the area of lower concentration—they move down their concentration gradient (the solution after diffusion is said to be at equilibrium).

Diffusion through the membrane

PASSIVE PROCESSES

- Substances may also diffuse through a membrane, if the membrane is permeable to them.

Several factors influence the diffusion rate of substances across plasma membranes:

1. **Steepness of the concentration gradient** (the greater the difference in concentration between the two sides of the membrane, the higher is the rate of diffusion).
2. **Temperature** (the higher the temperature, the faster the rate of diffusion).
3. **Mass of the diffusing substance** (the larger the mass of the diffusing particle, the slower its diffusion rate).
4. **Surface area** (the larger the membrane surface area available for diffusion, the faster is the diffusion rate).
5. **Diffusion distance** (The greater the distance over which diffusion must occur, the longer it takes).

DIFFUSION

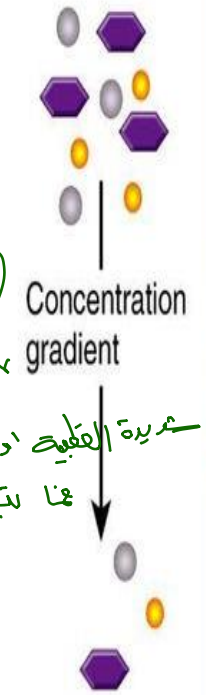
1- Simple diffusion

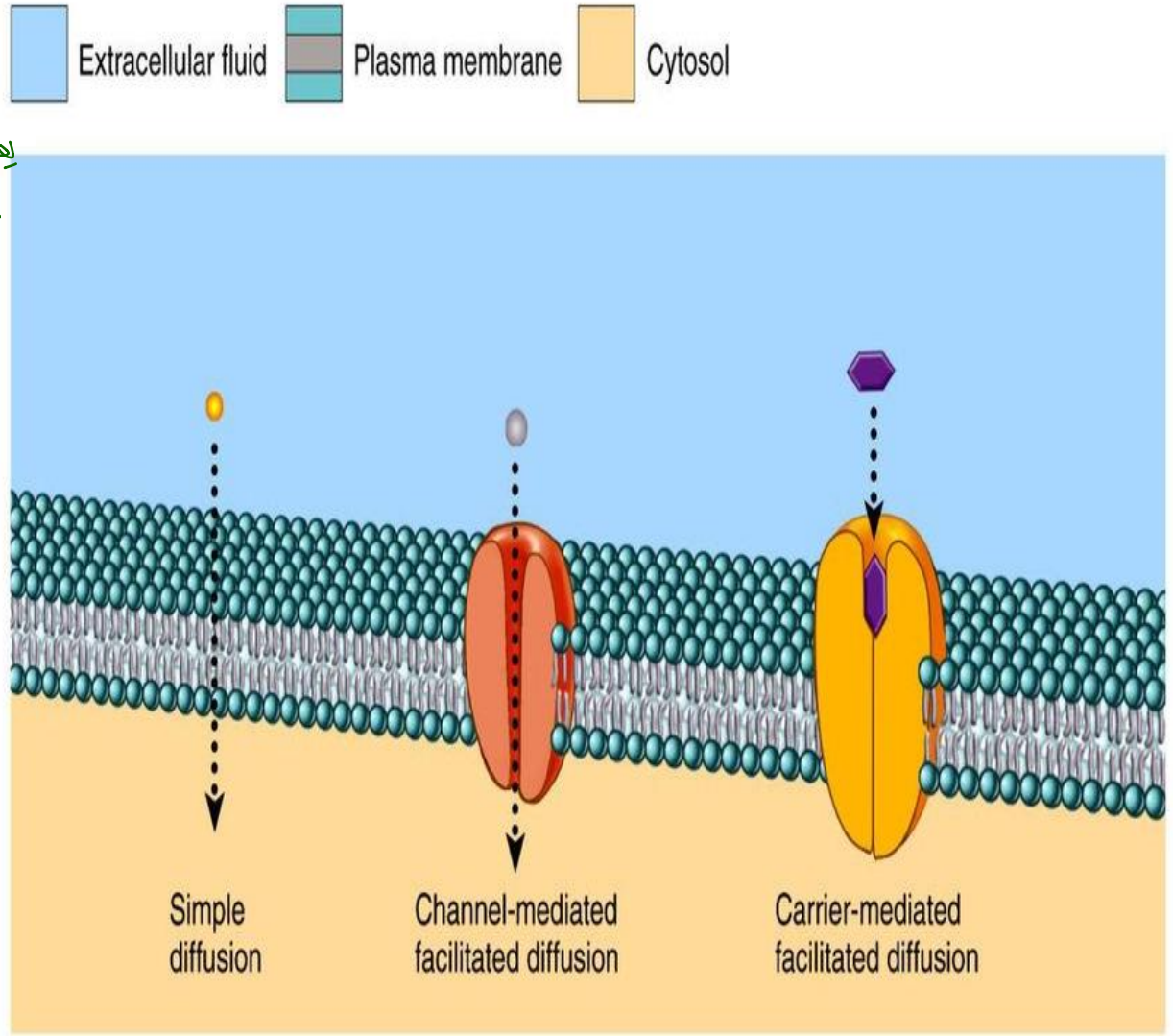
a substance moves across the lipid bilayer of the plasma membrane without the help of membrane transport proteins

2- Facilitated diffusion

channel-mediated facilitated diffusion, and carrier-mediated facilitated diffusion

A substance moves across the lipid bilayer aided by a channel protein or a carrier protein





DIFFUSION

Examples of simple diffusion

Nonpolar, hydrophobic molecules include oxygen, carbon dioxide, and nitrogen gases; fatty acids; steroids; and fat-soluble vitamins (A, D, E, and K) as well as small, uncharged polar molecules such as water, urea, and small alcohols.

Examples of facilitated diffusion

Too polar or highly charged solutes.

هاد النوع بنقسم لنوعين فرعيين :

FACILITATED DIFFUSION

هاد النوع ← بتمر المواد عبر قنوات بروتينية معينة بالغشاء، تسمى قنوات الأيونات (ion-channels) وهاي القنوات بتسمح بمرور الأيونات المعدنية (inorganic) اللي ما بتقدر تمر عبر الجزء الدهني لأنها hydrophilic.

الانتشار السهل عبر القنوات

1. Channel- mediated facilitated diffusion

- Most membrane channels are ion channels integral transmembrane proteins that allow passage of small, inorganic ions that are too hydrophilic to penetrate the nonpolar interior of the lipid bilayer.

بعض هاي القنوات اما بتكون [مفتوحة / مغلقة] ← بتحكم عشوائي، بينما في قنوات ثانية بتنفتح او تنغلق استجابة" لتغيرات كيميائية او كهربائية داخل او خارج الخلية.

- Some gated channels randomly alternate between the open and closed positions; others are regulated by chemical or electrical changes inside and outside the cell. When the gates of a channel are open, ions diffuse into or out of cells, down their electrochemical gradients.

بتنتقل الأيونات داخل او خارج الخلية حسب تدرجها الكهروكيميائي.

FACILITATED DIFFUSION

2. Carrier- mediated facilitated diffusion

- The solute binds more often to the carrier on the side of the membrane with a higher concentration of solute and is released on the other side after the carrier undergoes a change in shape.

- Once the concentration is the same on both sides of the membrane, solute molecules bind to the carrier on the cytosolic side and move out to the extracellular fluid.

- Substances that move across the plasma membrane by carrier mediated facilitated diffusion include glucose, fructose, galactose, and some vitamins.

OSMOSIS

- **Osmosis** is a type of diffusion that occurs only when a membrane is permeable to water but is not permeable to certain solutes.

والماء يتحرك عبر الغشاء البلازمي من منطقة تركيز ماء اعلى لمنطقة ذات تركيز ماء اقل: بمعنى آخر: الماء يتنقل عبر الغشاء حتى المنطقة من منطقة تحتوي على تركيز منخفض من المواد المذابة لمنطقة تحتوي على تركيز عالي من المواد المذابة

- In living systems, the solvent is water, which moves by osmosis across plasma membranes from an area of **higher water concentration to an area of lower water concentration**. In other words, water moves through a selectively permeable membrane **from an area of lower solute concentration to an area of higher solute concentration**.

1. Isotonic soln.
2. Hypotonic soln.
3. Hypertonic soln.

أنواع المحاليل بالنسبة للخلية:

OSMOSIS

هو محلول الي بتحافظ فيه الخلية ع شكلها وحجمها الطبيعي.

بهاد النوع من المحاليل ← بكون تركيز المواد المذابة اللي مقدرة ع عبور الغشاء متساوي داخل وخارج الخلية

- Any solution in which a cell maintains its normal shape and volume is an **isotonic solution**. The concentrations of solutes that cannot cross the plasma membrane are the same on both sides of the membrane in this solution.

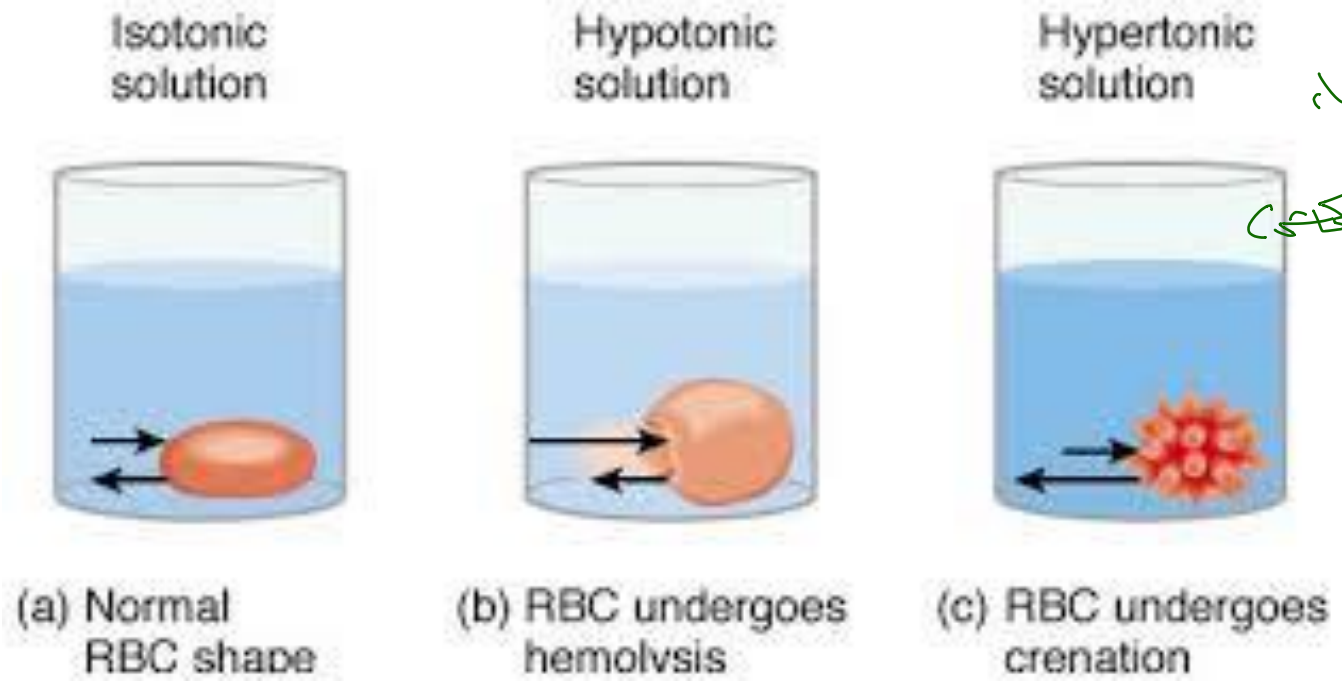
يعني: في حركة صافية للماء ← بدخل وبطلع بنفس المعدل، فبتضل الخلية زي ما هي.

- A different situation results if the cells are placed in **a hypotonic solution**, a solution that has lower concentration of solutes than the cytosol inside the cells. In this case, water molecules enter the cells faster than they leave, causing the cells to swell and eventually to burst (lysis).

هو محلول تركيز المواد المذابة فيه اقل من تركيزها بال cytosol جوا الخلية. لذلك الماء بتحرك الي جوا الخلية بسرعة أكبر من خروجه. كنتيجة لهيك اسمه: تنتفخ الخلية بسبب دخول الماء، وبعدها (بتنفجر - lysis) اذا دخل مي كتير جدا!

OSMOSIS

- A **hypertonic solution** has a higher concentration of solutes than does the cytosol inside cells. In such a solution, water molecules move out of the cells faster than they enter, causing the cells to shrink. Such shrinkage of cells is called crenation.



ACTIVE PROCESSES

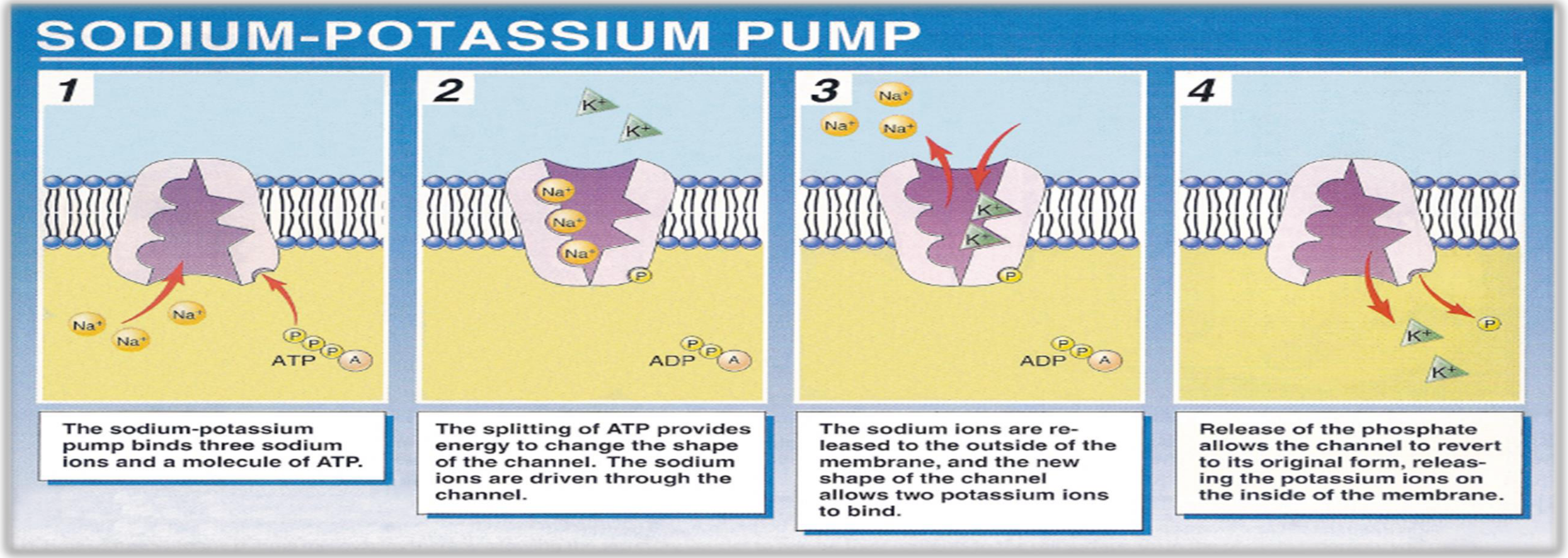
- **Two sources of cellular energy can be used to drive active transport:**

1. Energy obtained from hydrolysis of adenosine triphosphate (ATP) is the source in **primary active transport**.
2. Energy stored in an ionic concentration gradient is **the source in secondary active transport**.

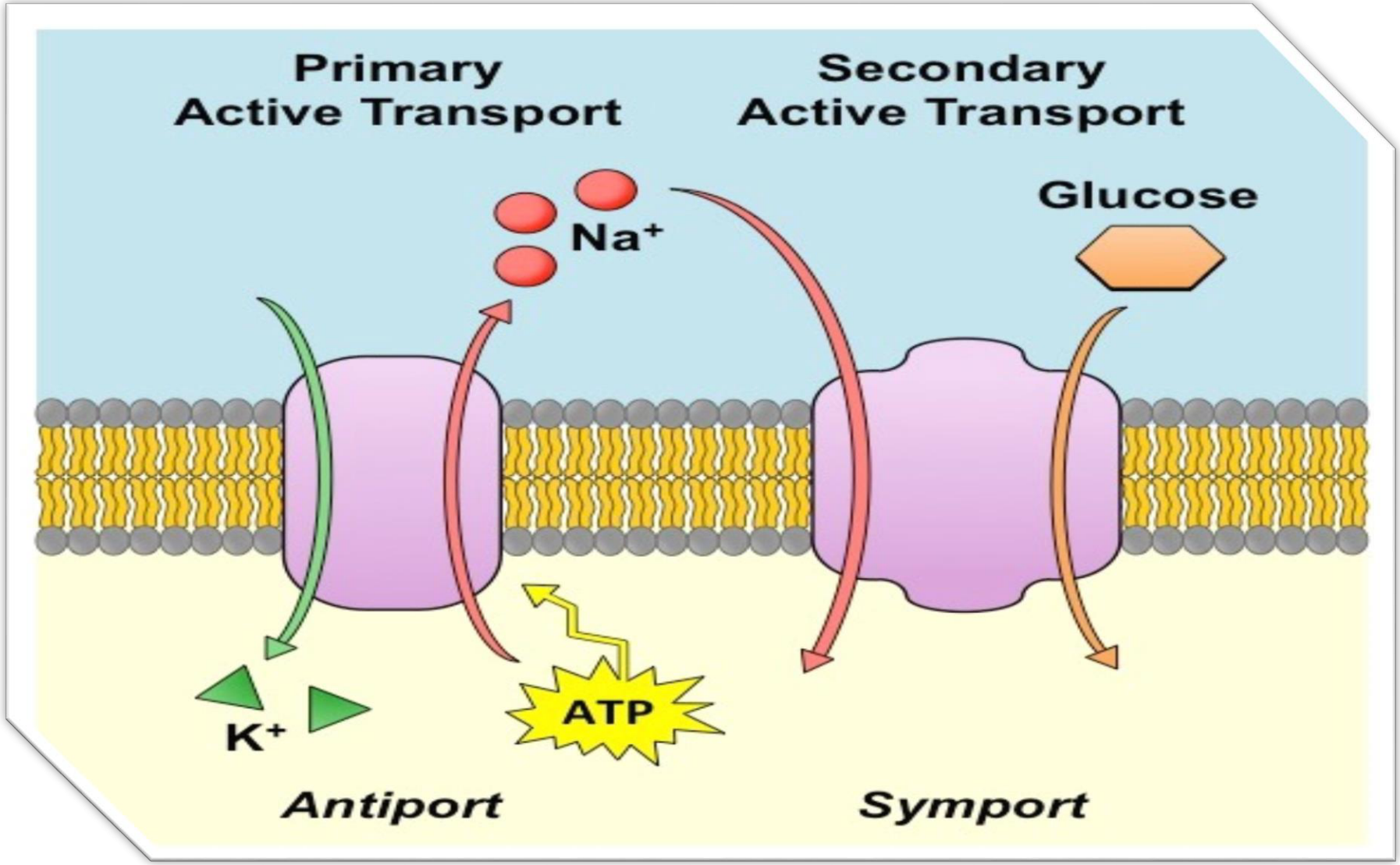
- Carrier proteins that mediate primary active transport are often called **pumps.**

ACTIVE PROCESSES

- The most prevalent primary active transport mechanism expels sodium ions from cells and brings potassium ions in (**sodium–potassium pump**). **All cells have thousands of sodium–potassium pumps in their plasma membranes.**



ACTIVE PROCESSES



TRANSPORT IN VESICLES

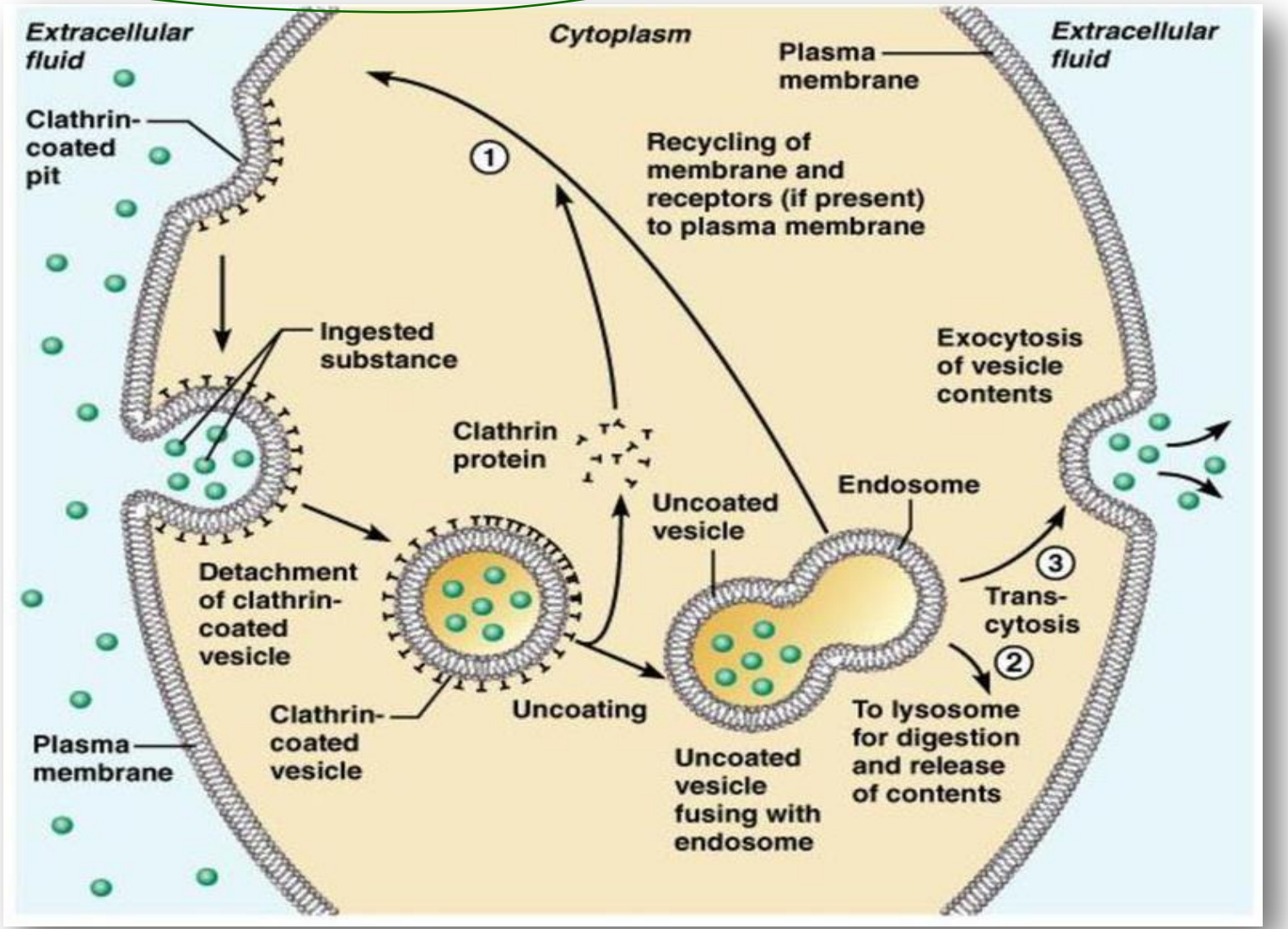
- During **endocytosis**, materials move into a cell in a vesicle formed from the plasma membrane.
- In **exocytosis**, materials move out of a cell by the fusion with the plasma membrane of vesicles formed inside the cell.
- Both endocytosis and exocytosis require energy supplied by ATP. Thus, **transport in vesicles is an active process.**

- **The three types of endocytosis:**

1. Receptor-mediated endocytosis.
2. Phagocytosis.
3. Bulk-phase endocytosis.

RECEPTOR-MEDIATED ENDOCYTOSIS

- Cells take up cholesterol-containing low-density lipoproteins (LDLs), transferrin (an iron-transporting protein in the blood), some vitamins, antibodies, and certain hormones by receptor-mediated endocytosis.



* LDLs
* Transferrin
* some vitamins.
* Anti-bodies
* some hormones.

RME

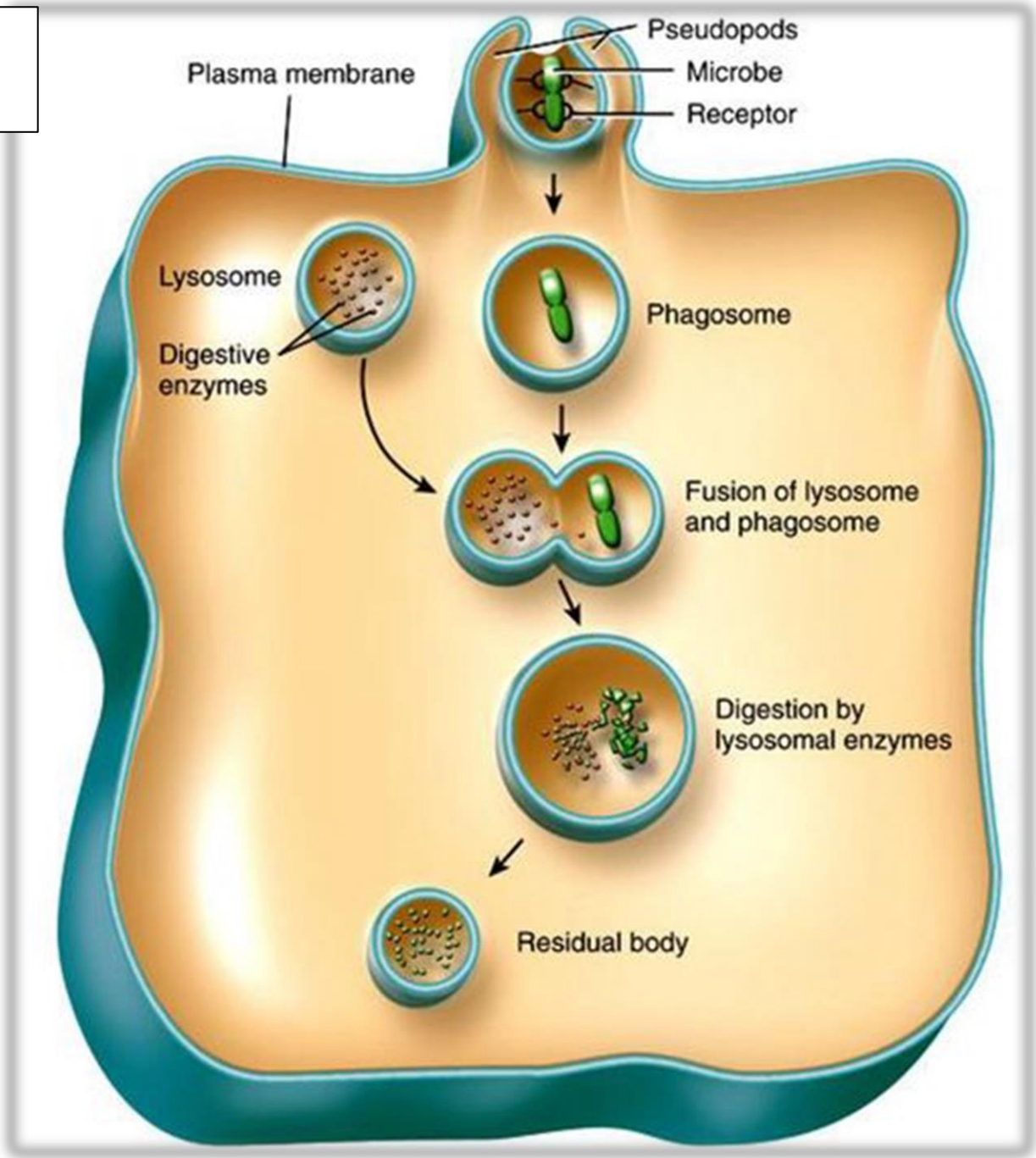
PHAGOCYTOSIS

- **Phagocytosis** is a form of endocytosis in which the cell engulfs large solid particles, such as worn-out cells, whole bacteria, or viruses.

- Two main types of phagocytes are macrophages, located in many body tissues, and neutrophils, a type of white blood cell.

PHAGOCYTOSIS

- Any undigested materials in the phagosome remain indefinitely in a vesicle called **a residual body**. The residual bodies are then either secreted by the cell via exocytosis or they remain stored in the cell.



(هاي هي الطريقة العامة لدخول الخلية)

BULK-PHASE ENDOCYTOSIS (PINOCYTOSIS)

وهي بتدخل كل المواد الخلية بجوا السائل الخارج الخلية مع القطرات.

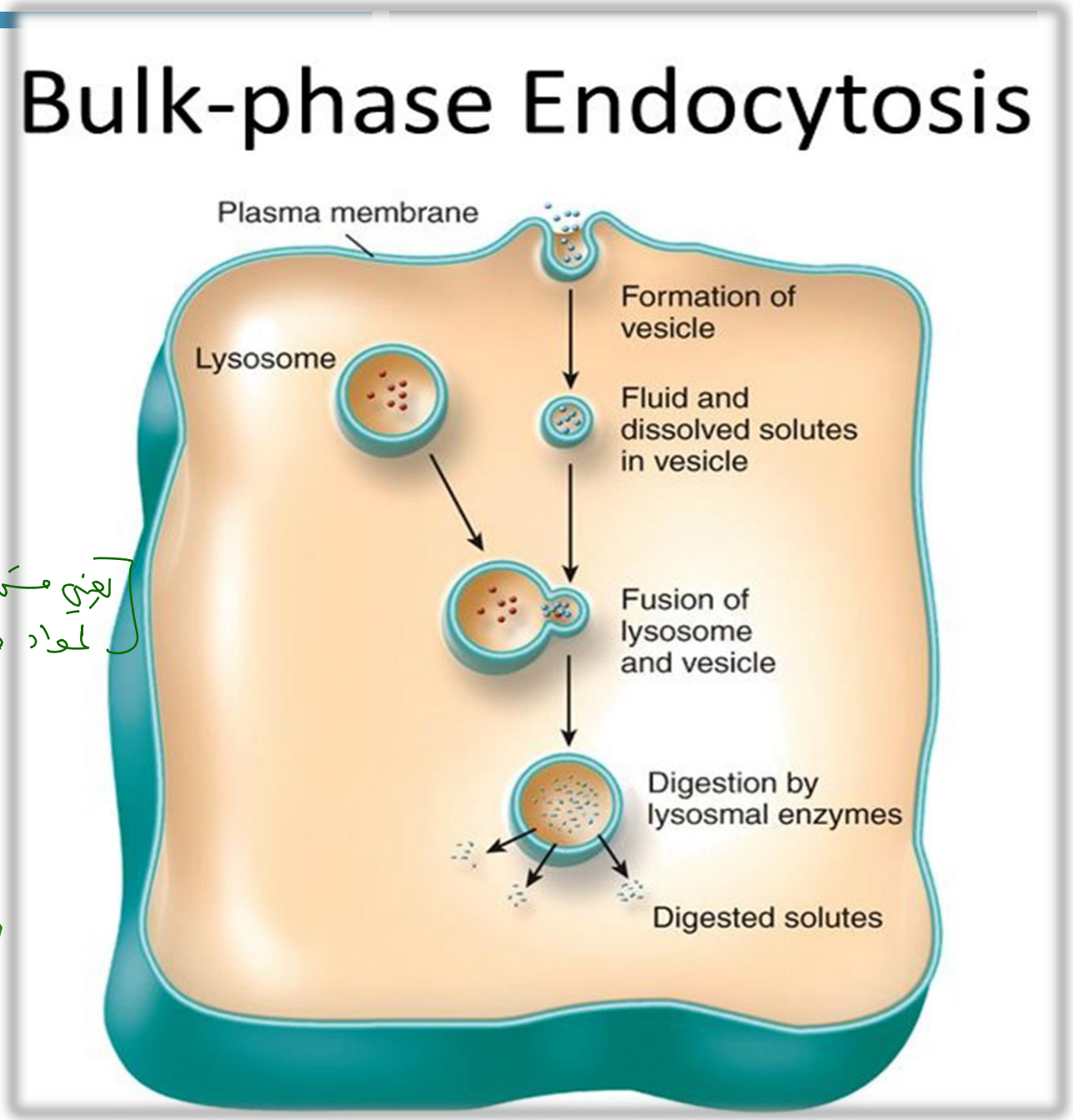
- Bulk-phase endocytosis is a form of endocytosis in which tiny droplets of extracellular fluid are taken up (all solutes dissolved in the extracellular fluid are brought into the cell.).

- **No receptor proteins are involved.**

- Bulk-phase endocytosis occurs in most cells, especially absorptive cells in the intestines and kidneys.

- The resulting smaller molecules leave the lysosome to be used elsewhere in the cell.

هاي القطرات بعد ما تدخل لداخل الخلية، راح تندمج مع الـ lysosomes، حيث يتم تحليل محتواها للجزيئات أصغر، ثم ستُستخدم هاي الجزيئات بأماكن تانية جوا الخلية.



EXOCYTOSIS

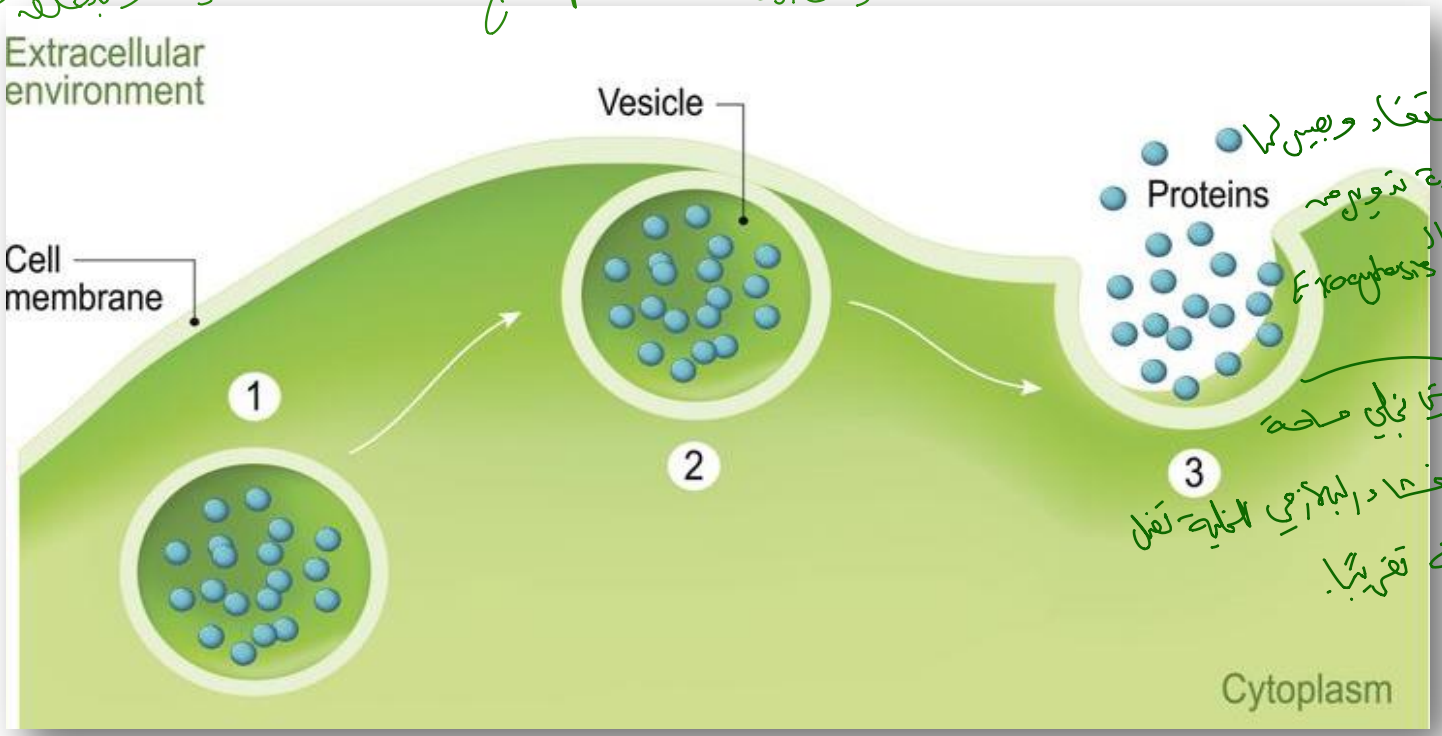
- In contrast with endocytosis, which brings materials into a cell, exocytosis releases materials from a cell.

- All cells carry out exocytosis, but it is especially important in two types of cells:

(1) secretory cells that liberate digestive enzymes, hormones, mucus, or other secretions and (2) nerve cells that release substances called neurotransmitters.

EXOCYTOSIS

- In some cases, wastes are also released by exocytosis. During exocytosis, membrane-enclosed vesicles called **secretory vesicles** form inside the cell, fuse with the plasma membrane, and release their contents into the extracellular fluid.



Segments of the plasma membrane lost through endocytosis are recovered or recycled by exocytosis. The balance between endocytosis and exocytosis keeps the surface area of a cell's plasma membrane relatively constant.

TRANSCYTOSIS

- Vesicles **undergo endocytosis on one side of a cell, move across the cell, and then undergo exocytosis on the opposite side**.

هاي العملية غالبًا بتصير بالخلايا المبطنة للأوعية الدموية Endothelial cells

- **Transcytosis occurs most often across the endothelial cells that line blood vessels** and is a means for materials to move between blood plasma and interstitial fluid.

هي طريقة لنقل المواد بين الأوعية الدموية والسائل بين الخلايا (Interstitial fluid)

- For instance, when a woman is pregnant, some of her antibodies cross the placenta into the fetal circulation via transcytosis.

مثلاً.

عشان تعطي للجنين مناعة مؤقتة ضد بعض الأمراض.

النوع 🔷	يحتاج طاقة (ATP) ⚡	اتجاه الحركة 🔄	الآلية / الطريقة 🧩
Simple Diffusion (الانتشار البسيط)	❌ لا	من الأعلى إلى الأقل تركيزًا	تمر الجزيئات مباشرة عبر الطبقة الدهنية بدون بروتين
Facilitated Diffusion – Channel-mediated	❌ لا	من الأعلى إلى الأقل تركيزًا	تمر الأيونات عبر قنوات بروتينية (Ion channels)
Facilitated Diffusion – Carrier-mediated	❌ لا	من الأعلى إلى الأقل تركيزًا	مادة ترتبط ببروتين ناقل يغيّر شكله وينقلها
Osmosis (الانتشار الأسموزي)	❌ لا	من منطقة ماء أعلى إلى أقل (أو من مذاب أقل إلى أكثر)	حركة الماء عبر غشاء شبه منفذ
Primary Active Transport (النقل النشط الأولي)	✅ نعم	من الأقل إلى الأعلى تركيزًا	مضخّات تستخدم طاقة الـ ATP مباشرة
Secondary Active Transport (النقل النشط الثانوي)	✅ نعم (بطريقة غير مباشرة)	عكس تدرج التركيز	يعتمد على طاقة تدرج الأيونات الناتج عن النقل الأولي
Receptor-Mediated Endocytosis	✅ نعم	إلى داخل الخلية	دخول مواد محددة ترتبط بمستقبلات
Phagocytosis (البلعمة)	✅ نعم	إلى داخل الخلية	ابتلاع جسيمات صلبة كبيرة
Bulk-Phase / Pinocytosis (شرب الخلية)	✅ نعم	إلى داخل الخلية	إدخال قطرات من السائل خارج الخلية بدون مستقبلات
Exocytosis (الإخراج الخلوي)	✅ نعم	إلى خارج الخلية	تندمج الحويصلات مع الغشاء وتُفرغ محتواها
Transcytosis (النقل عبر الخلية)	✅ نعم	من جانب إلى جانب آخر للخلية	Endocytosis من جهة + Exocytosis من الجهة الأخرى