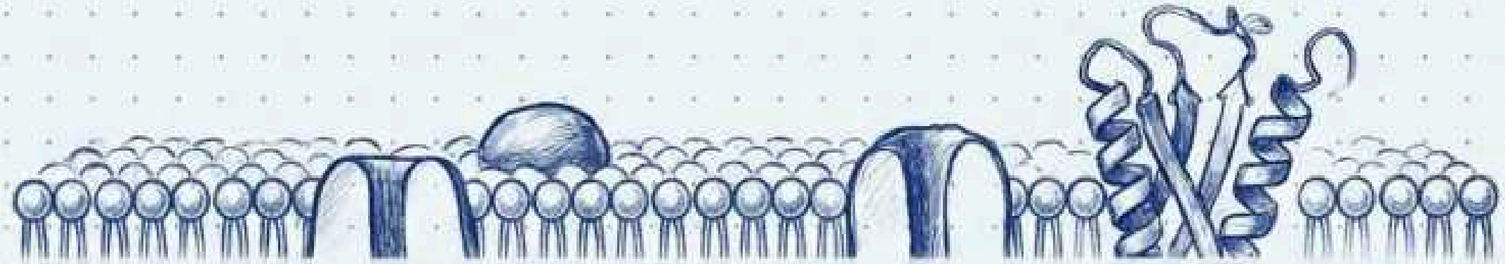
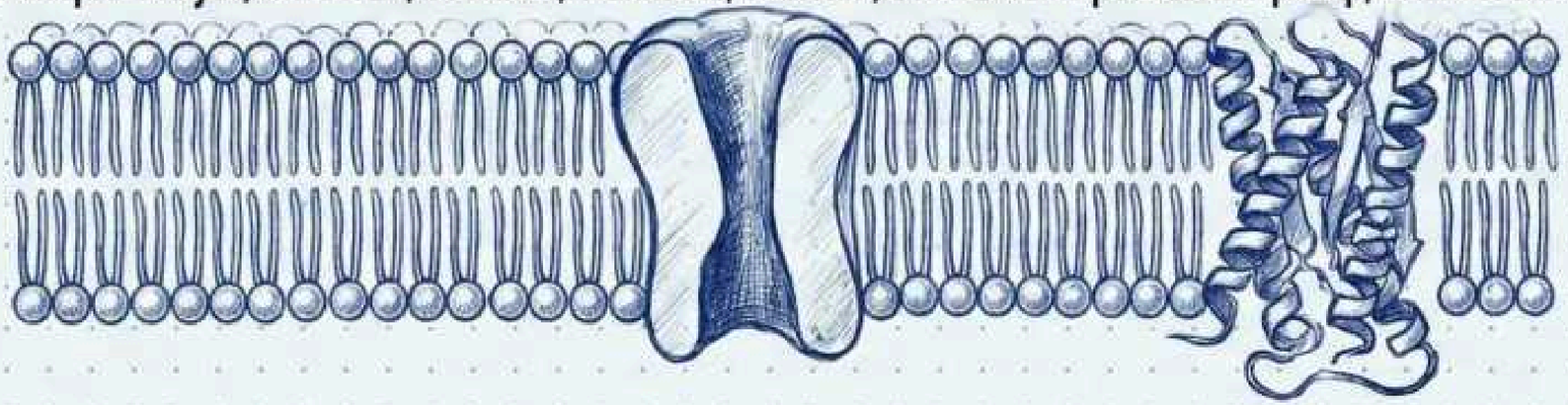
¶ 1.1

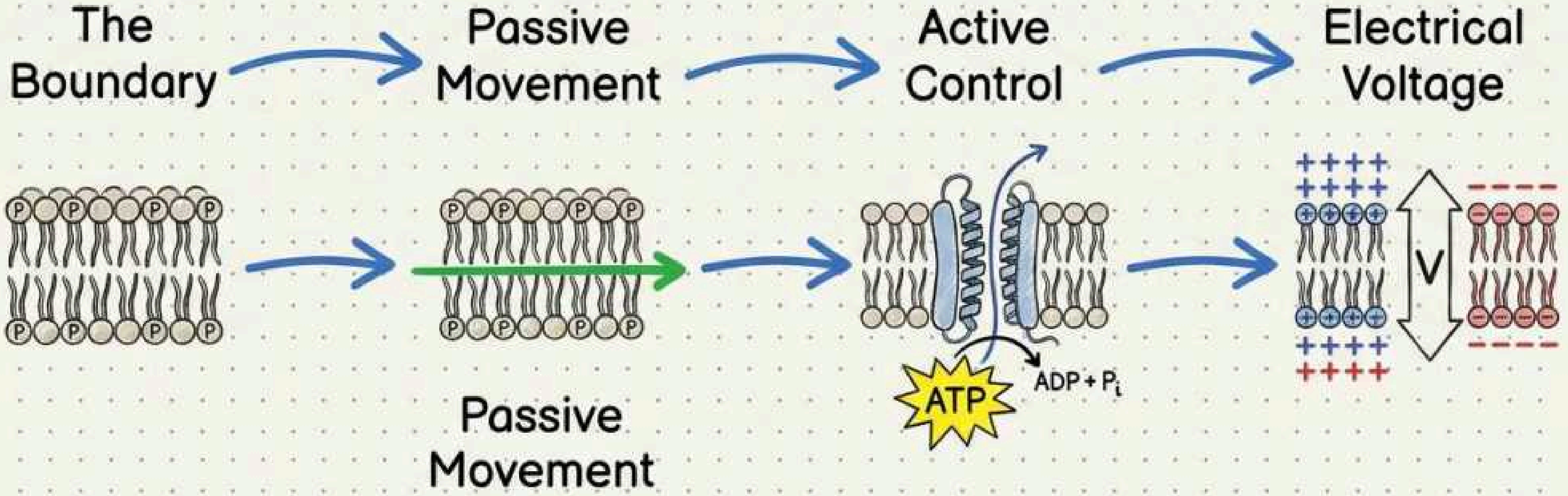


Lecture 1 – Membranes and Transport

The phospholipid bilayer, diffusion, osmosis, channels, carriers, the sodium-potassium pump, and the Nernst equation.



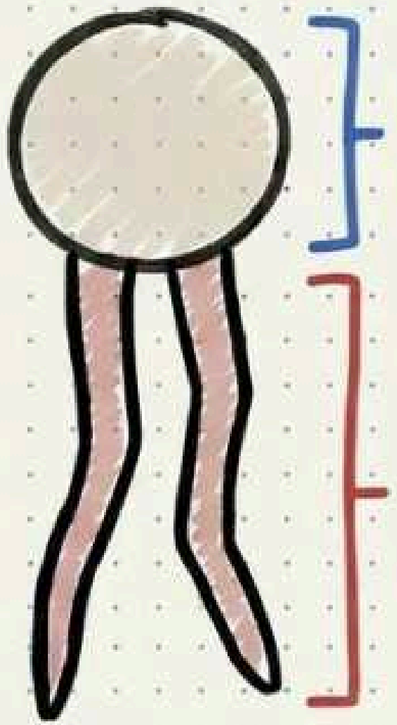
¶ 1.2



We will build the membrane, understand why substances cannot drift across, study transport methods, and calculate the electrical voltage created by gradients.

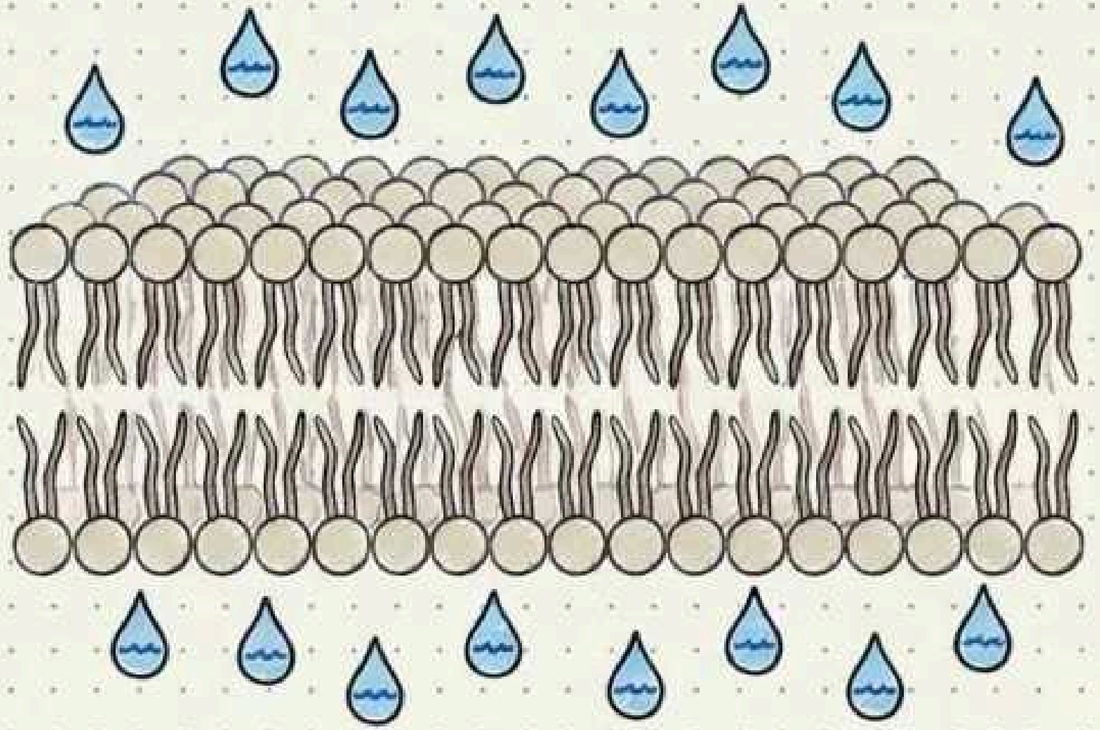
Structure follows from chemistry.

¶ 1.3



Hydrophilic Head
(Attracts water)

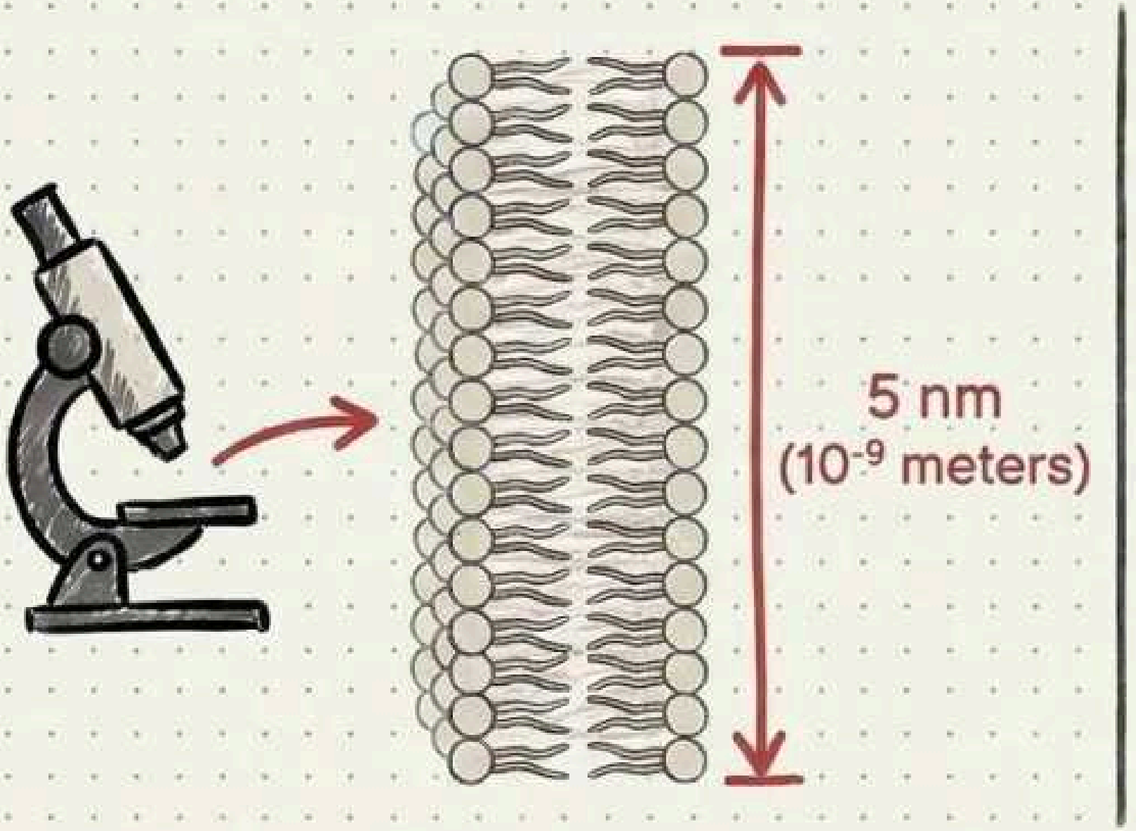
Hydrophobic
Fatty Tails
(Avoids water)

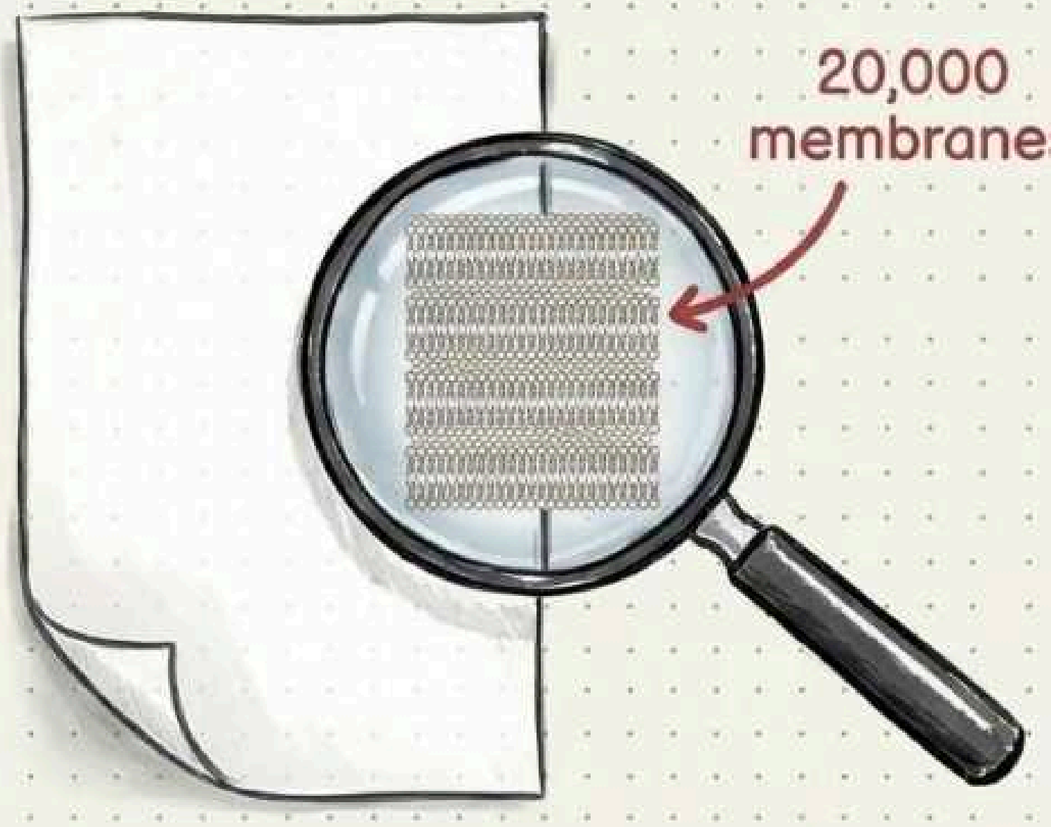


No one builds this layer. It
It forms spontaneously as the
lowest-energy arrangement.

The astonishing precision of five nanometers.

¶ 1.4

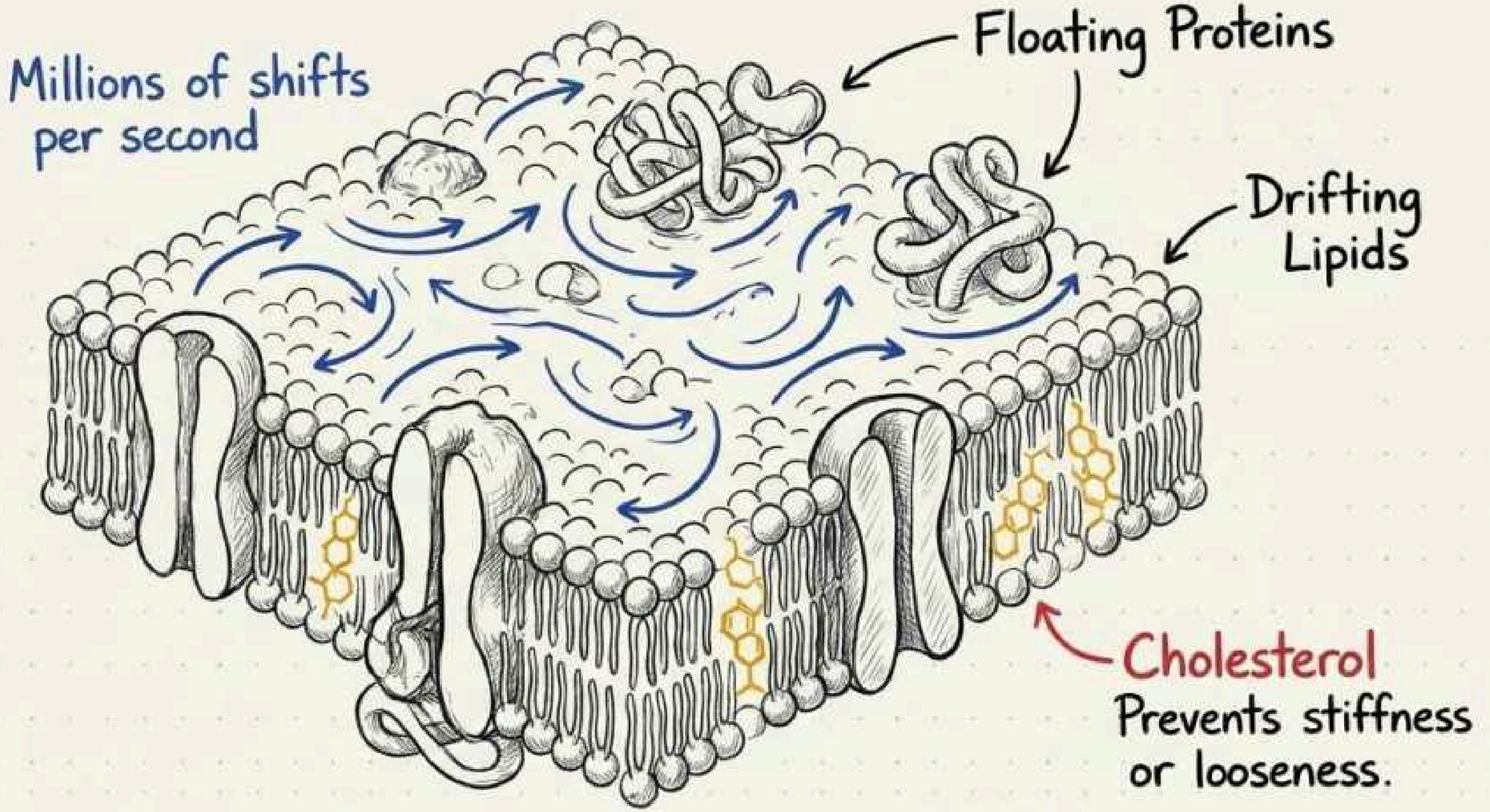




This unimaginably thin film successfully separates the living interior of a cell from its surroundings.

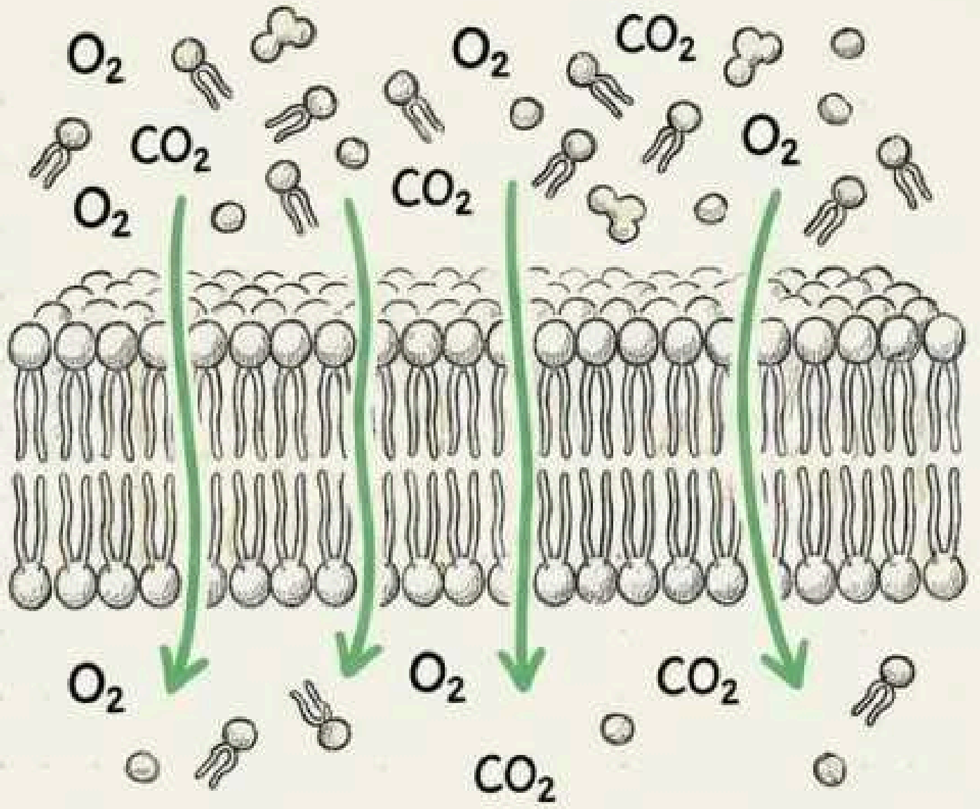
The Fluid Mosaic Model (Singer & Nicolson, 1972).

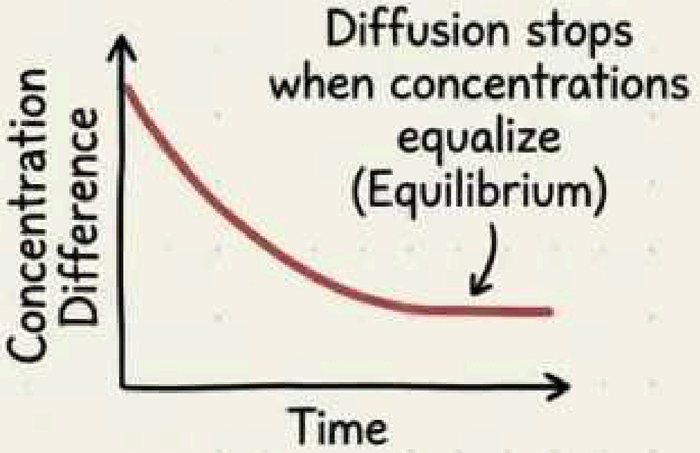
¶ 1.5



Simple diffusion requires no energy.

¶1.6

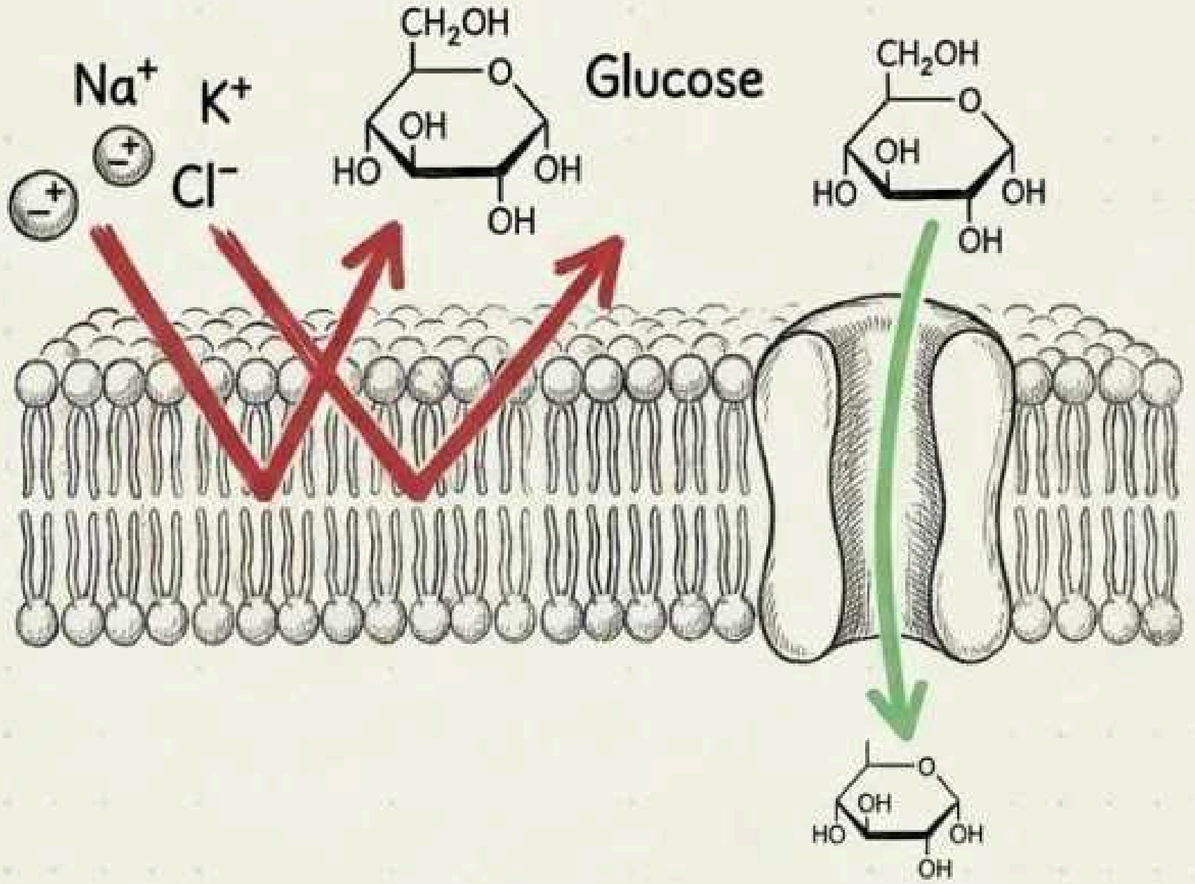




High Concentration → Low Concentration.
Driven entirely by random motion.

Charged and large polar molecules require cellular control.

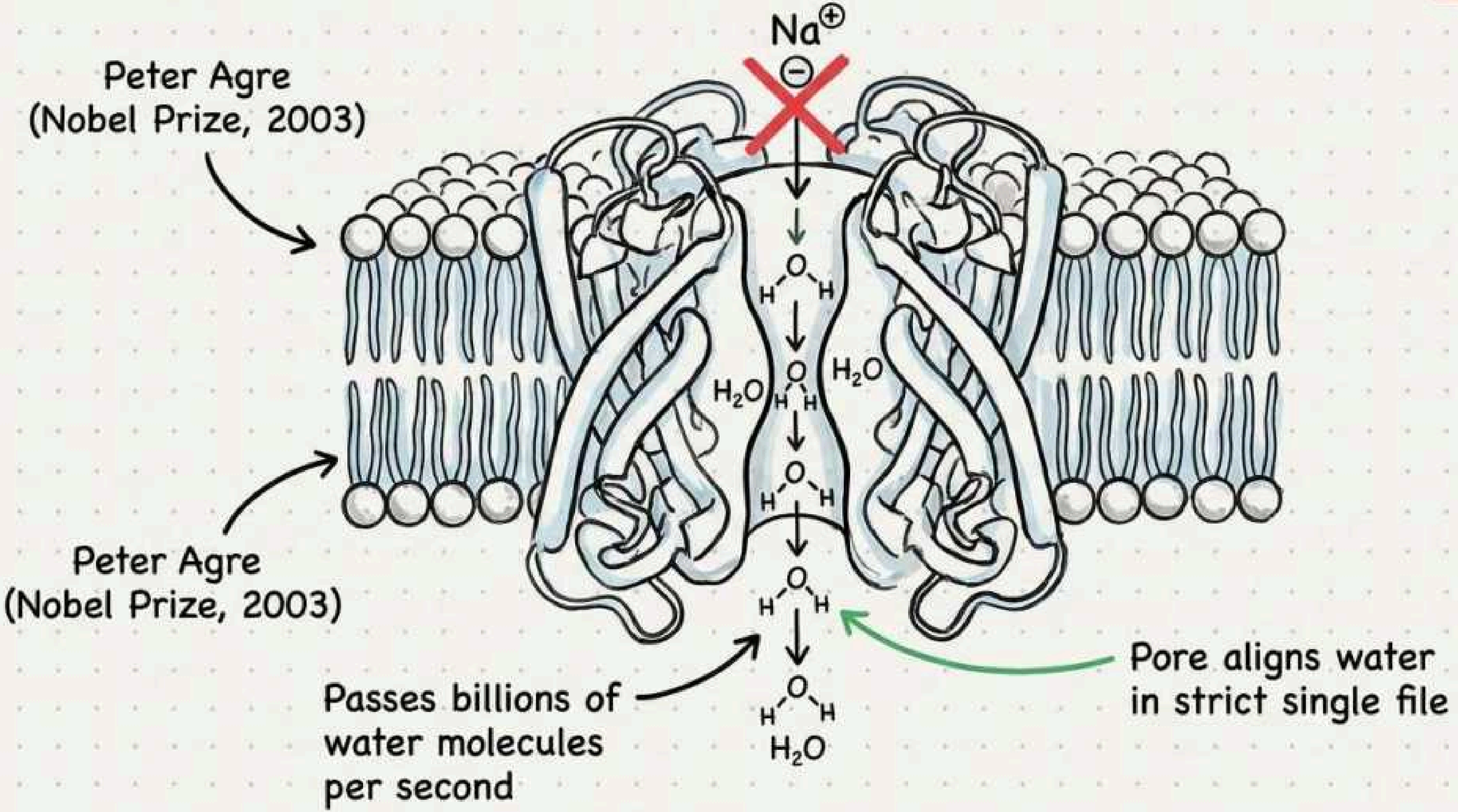
¶ 1.7



Without help, these substances cross extremely slowly.
Membrane proteins give the cell power over what enters and leaves.

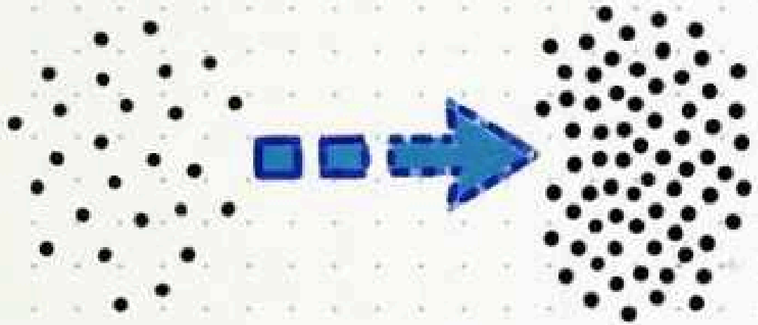
Aquaporins and the rapid transit of water.

¶ 1.8



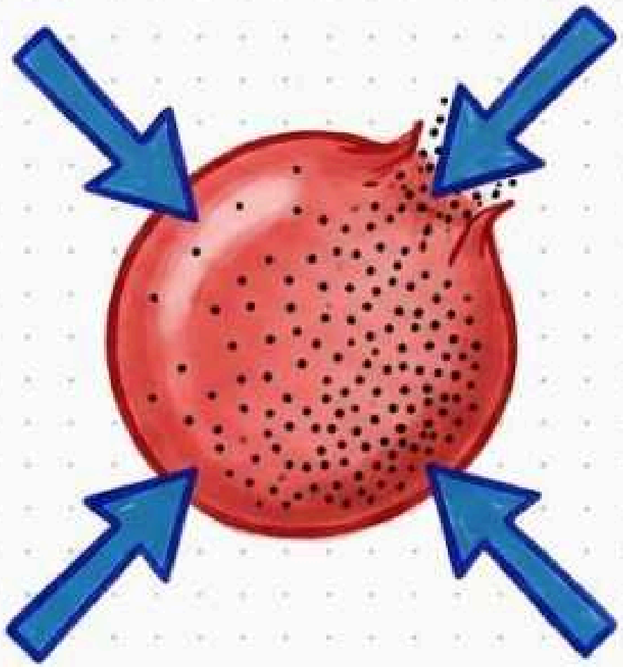
Osmosis chases the highest particle count.

¶ 1.9

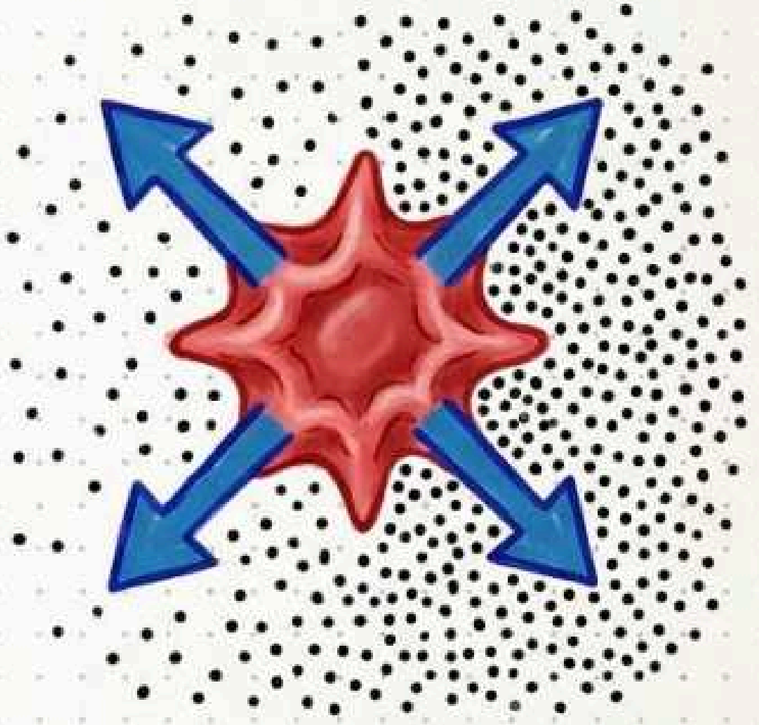


Water moves toward more dissolved particles.

Pure Water



Salty Water



Cells care about the total count of particles.

¶ 1.10

Calculating a blood-matched saline solution.

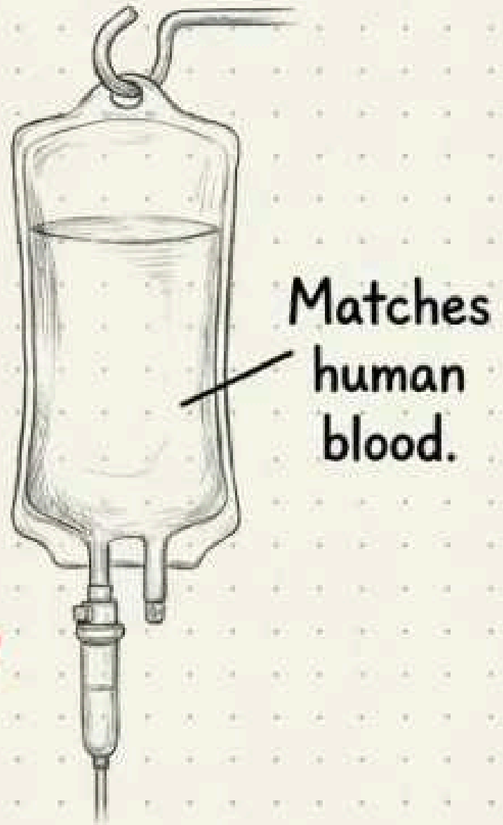
Step 1: 0.9% NaCl = 9 grams of salt per liter

Step 2: $\frac{9\ \text{g/L}}{58.4\ \text{g/mol (molar mass)}} = 0.154$ moles per liter

Step 3: Each NaCl unit splits into 2 ions (Na^+ and Cl^-)

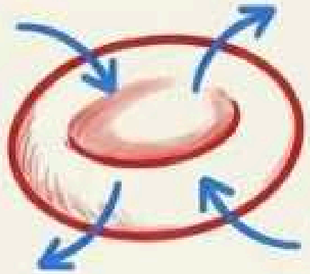
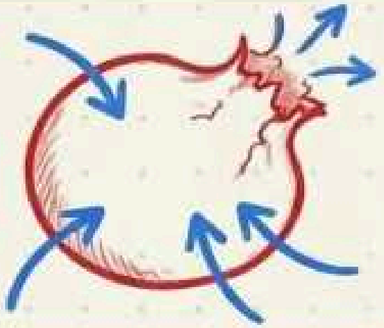
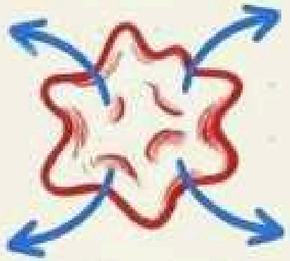
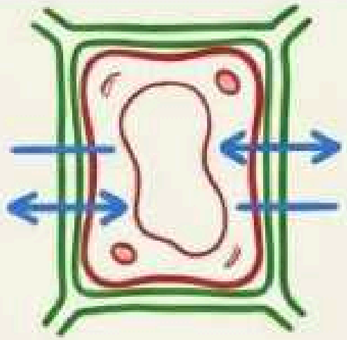
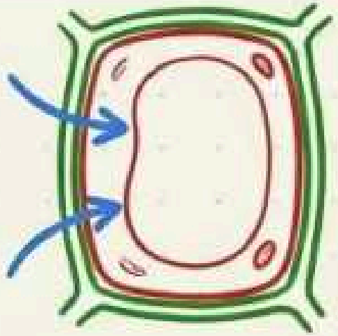
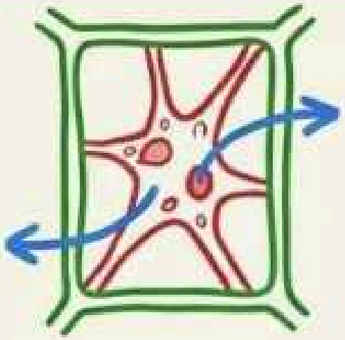
Step 4: $0.154 \times 2 = 308$ milliosmoles per liter

308 mOsm/L



The Tonicity Matrix.

¶ 1.11

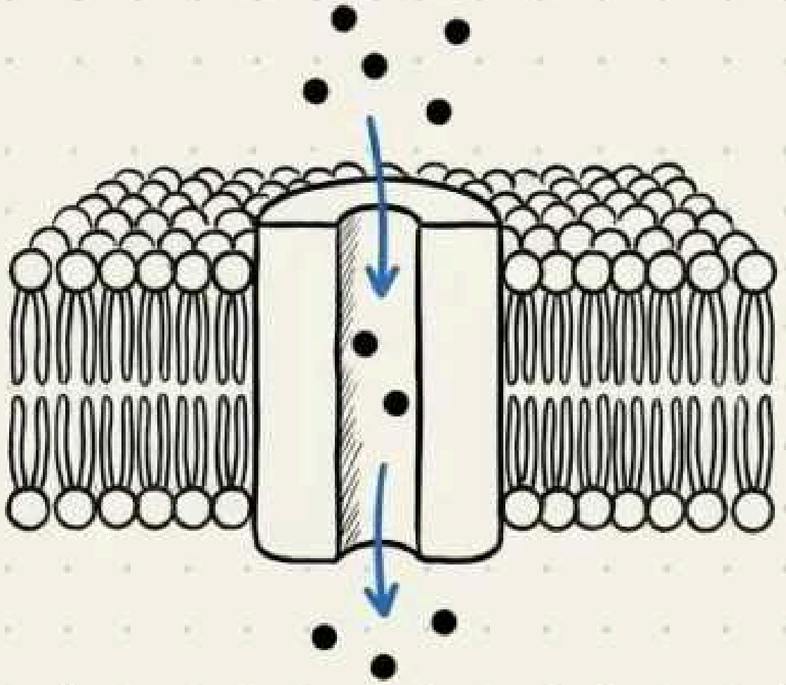
	Isotonic (matching particle count)	Hypotonic (fewer particles outside)	Hypertonic (more particles outside)
Animal Cells (No Wall)			
Plant/Bacteria (Rigid Wall)			

Cell walls provide physical resistance, which is why the human body (lacking walls) must strictly maintain an isotonic environment.

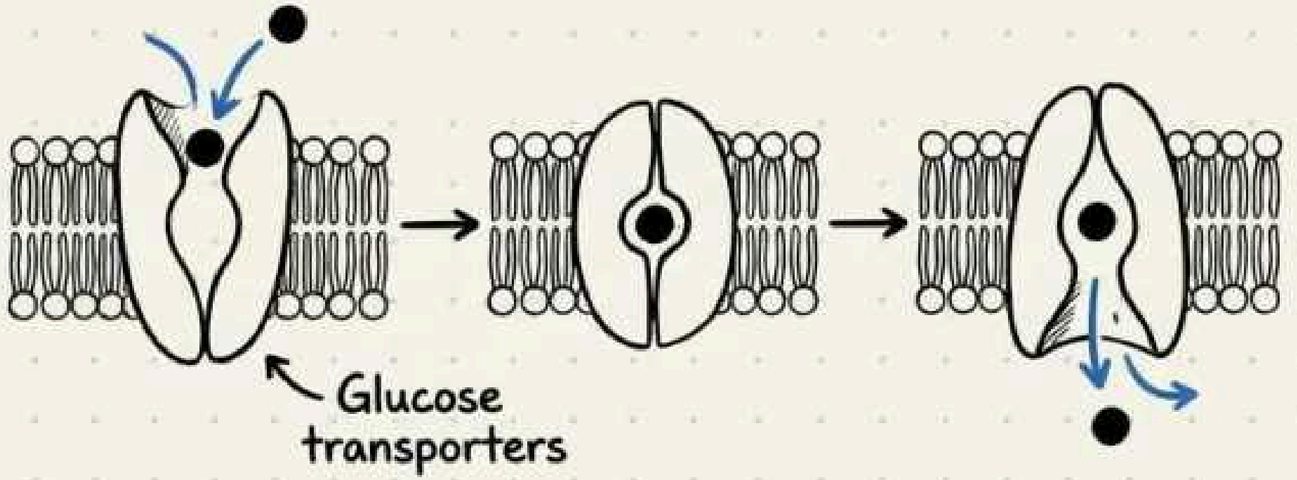
Facilitated diffusion: Channels vs. Carriers.

¶ 1.12

Channels



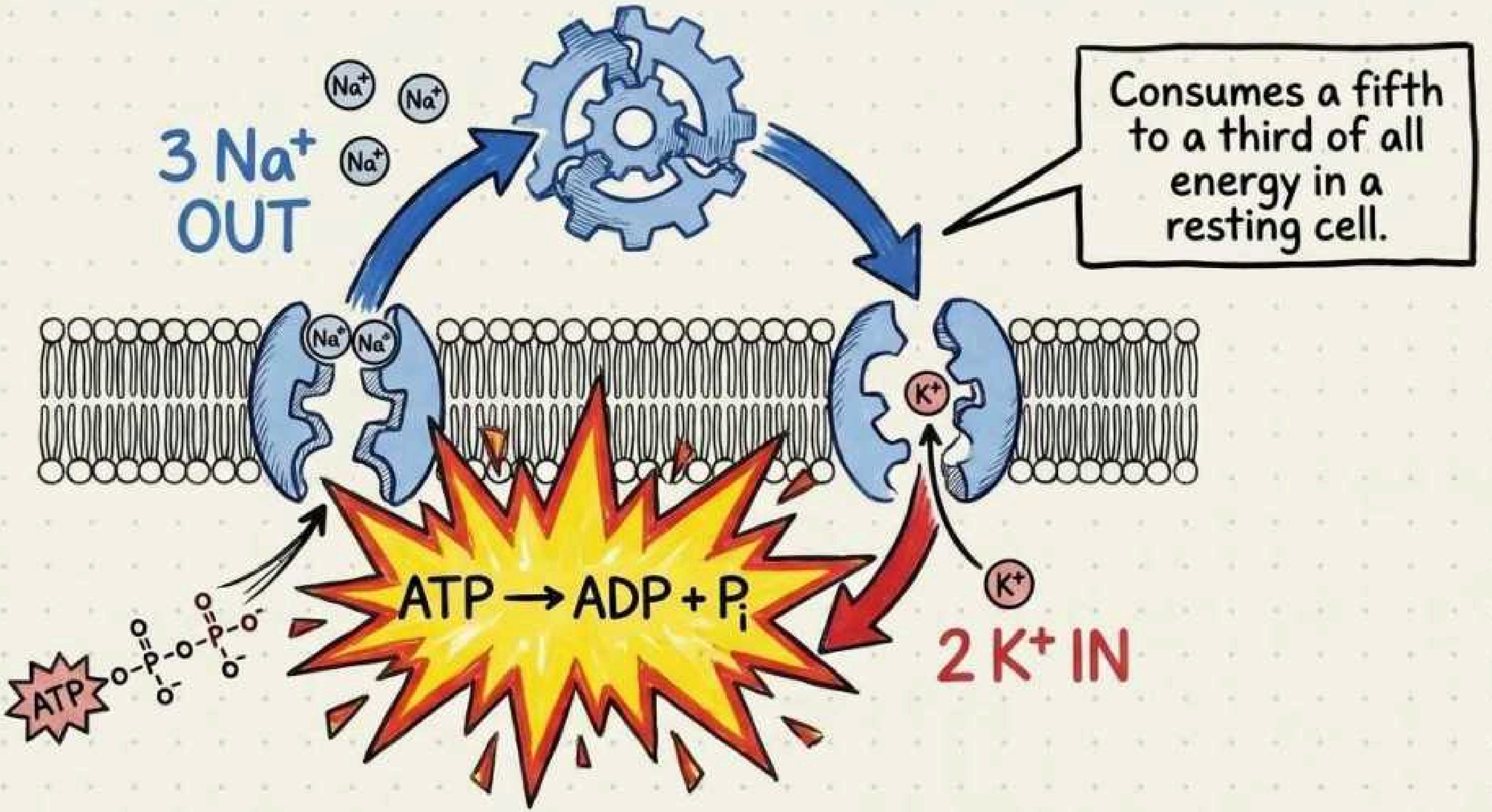
Carriers



Carriers operate at a set rate depending on protein count. They can become saturated.

Active transport spends energy to fight gradients.

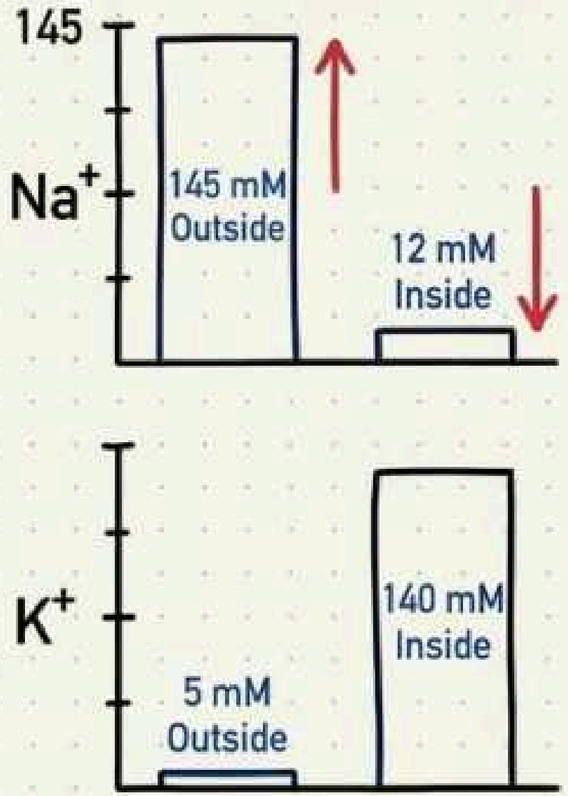
¶ 1.13

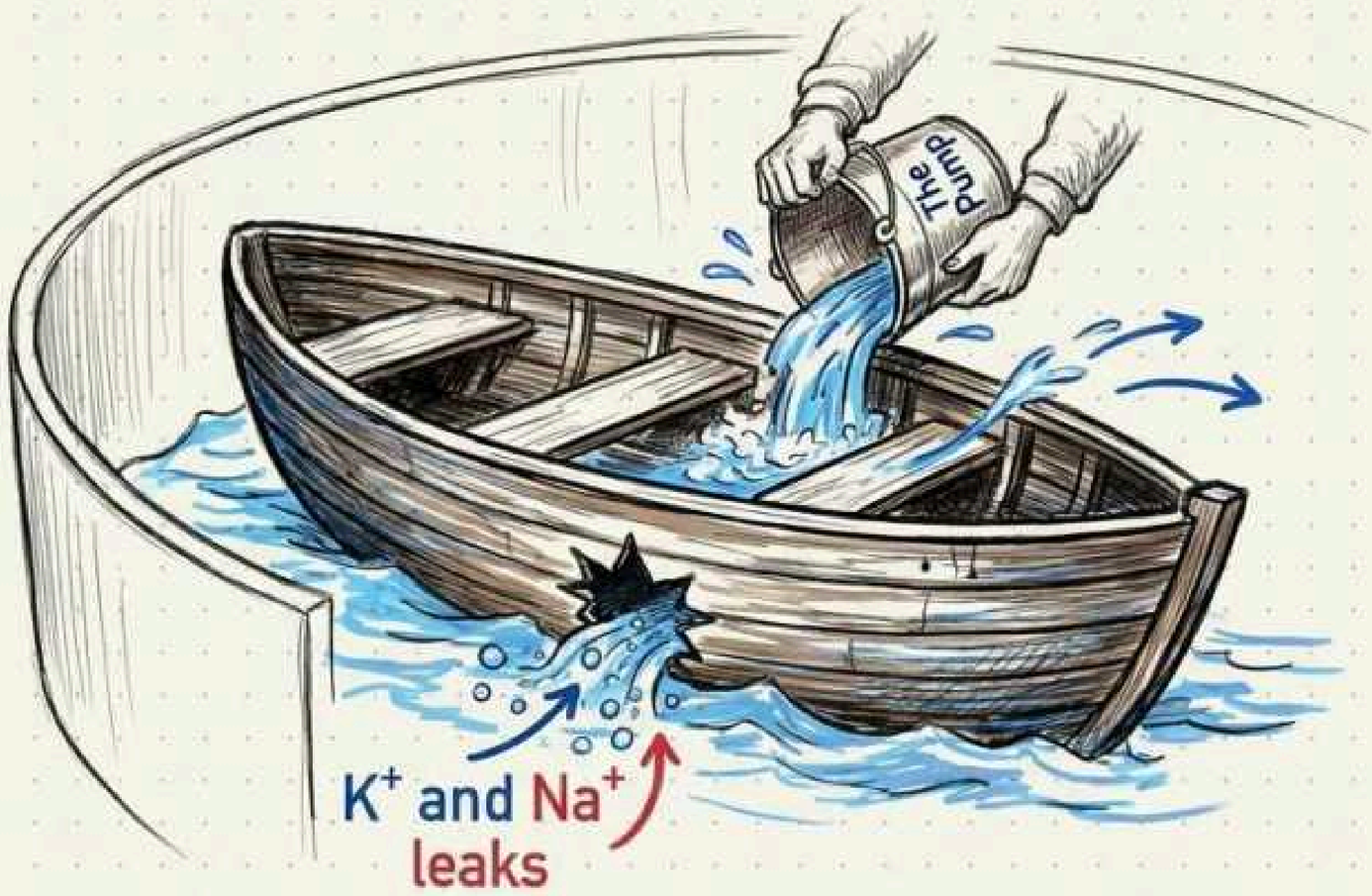


Building a steep imbalance.

¶ 1.14

Ion Concentration Contrasts

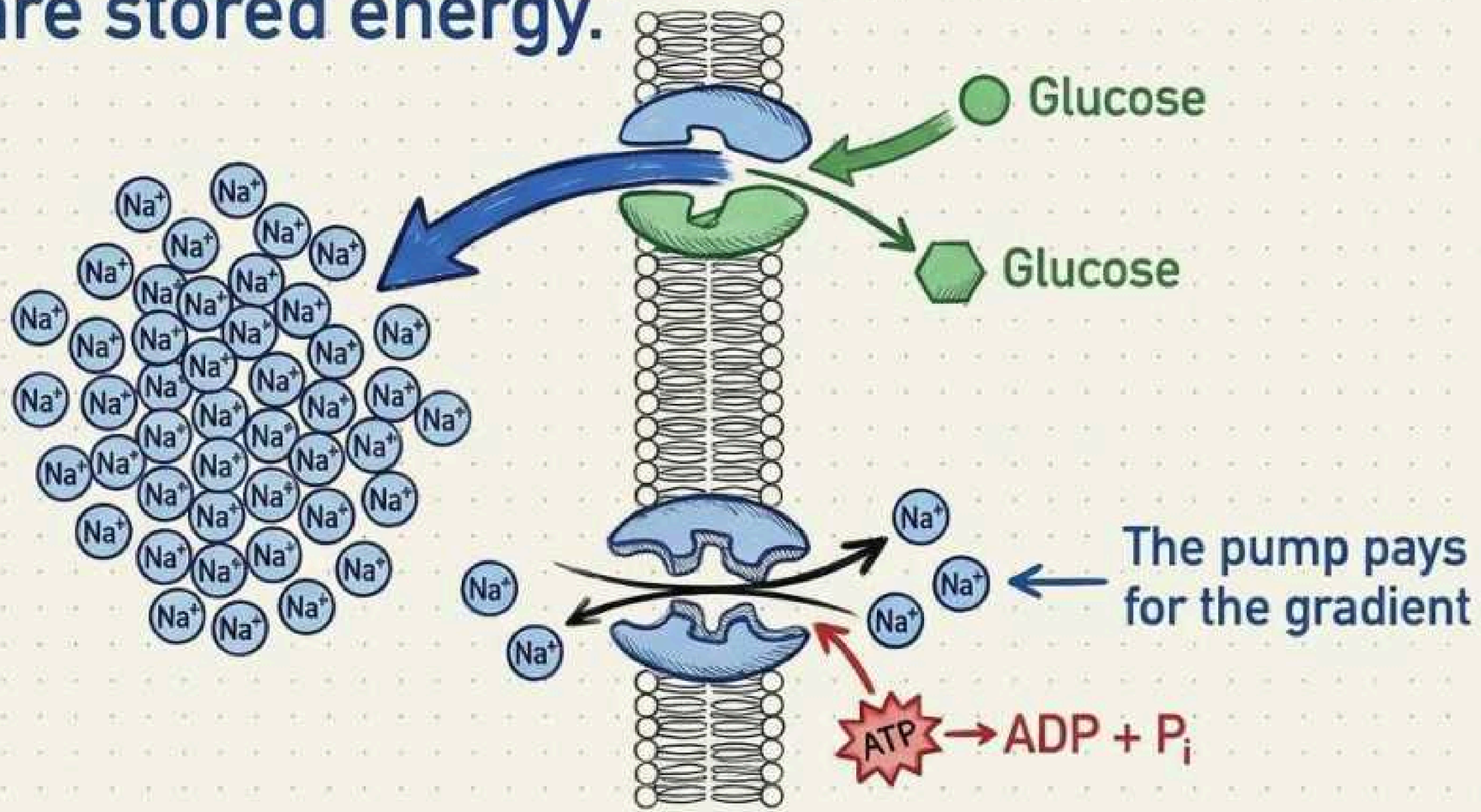




The pump keeps gradients steady against constant leaks, bailing a boat that never stops leaking.

¶ 1.15

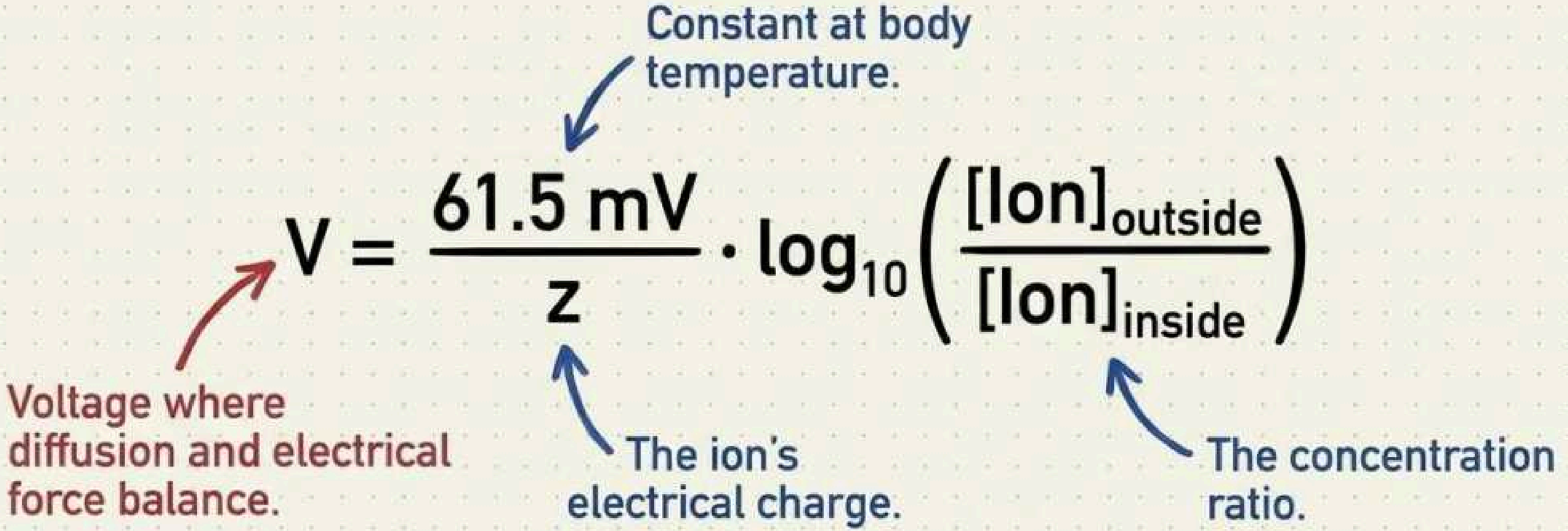
Secondary Active Transport: Gradients are stored energy.



The Na^+ gradient acts as payment. This is how you absorb sugar from food without directly spending ATP on the glucose carrier.

The Nernst Equation: Gradients produce voltage.

¶1.16



This formula calculates the exact electrical voltage created by the gradient of a single charged ion.

Calculating electrical equilibrium.

¶ 1.17

K^+

Ratio is $\frac{5}{140}$.

$\log_{10} \approx -1.45$.

$V \approx -89$ mV.

Sits near −70 mV because the membrane leaks mostly potassium.



Na^+

Ratio is $\frac{145}{12}$.

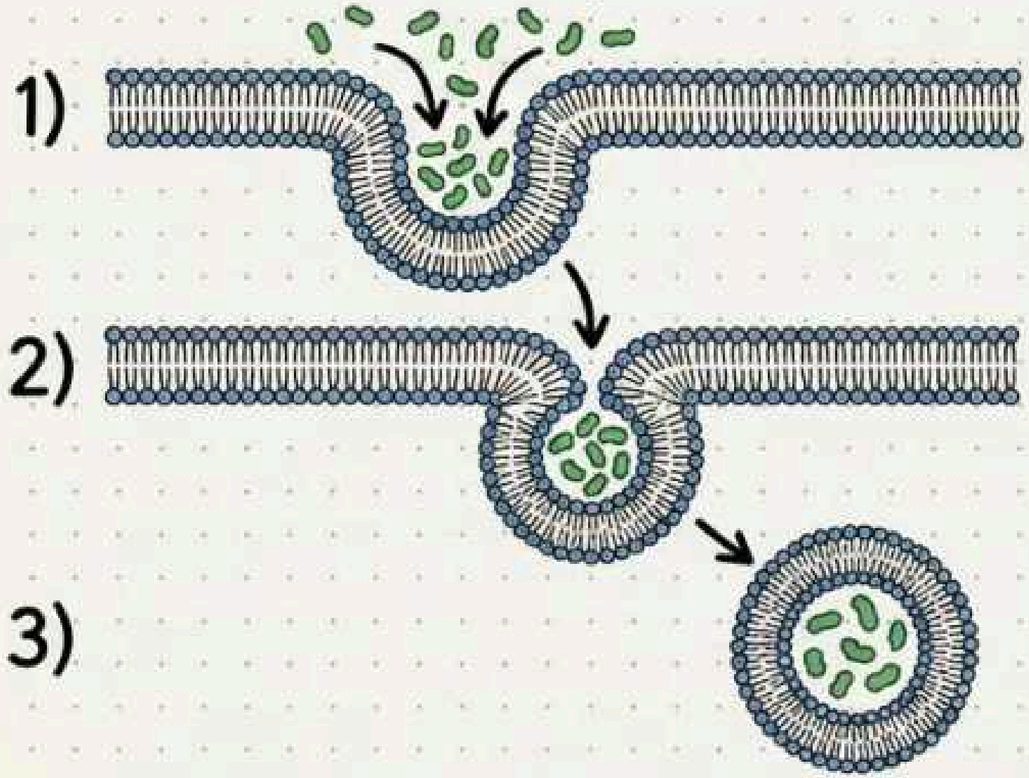
$\log_{10} \approx +1.08$.

$V \approx +67$ mV.

Moving bulk material costs energy.

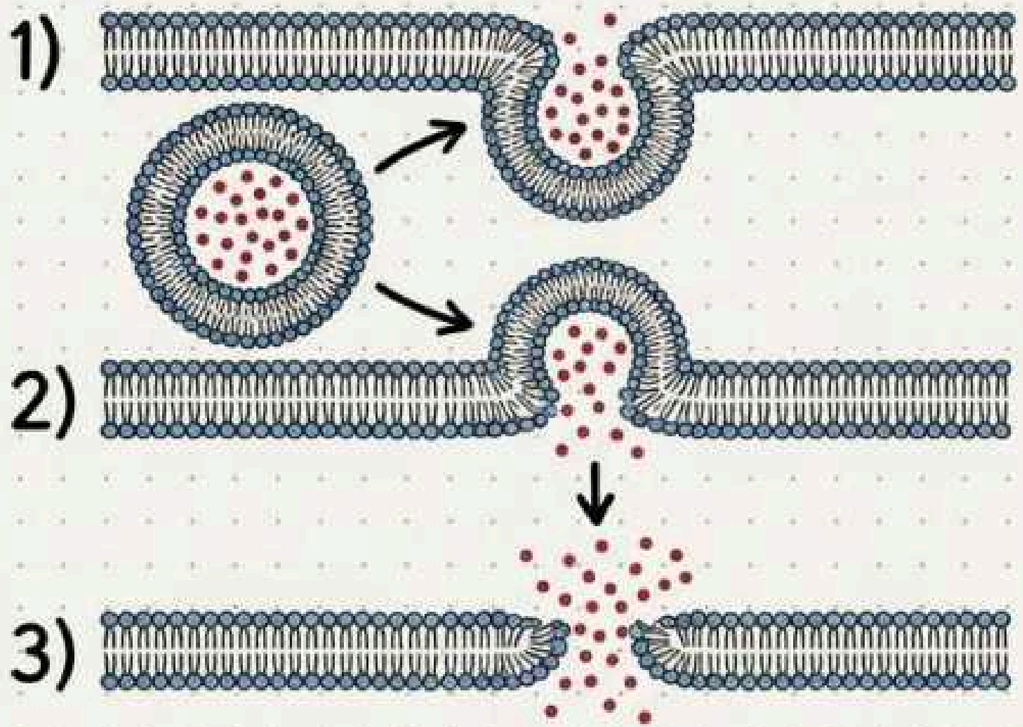
¶ 1.18

Endocytosis



White blood cells engulfing bacteria

Exocytosis

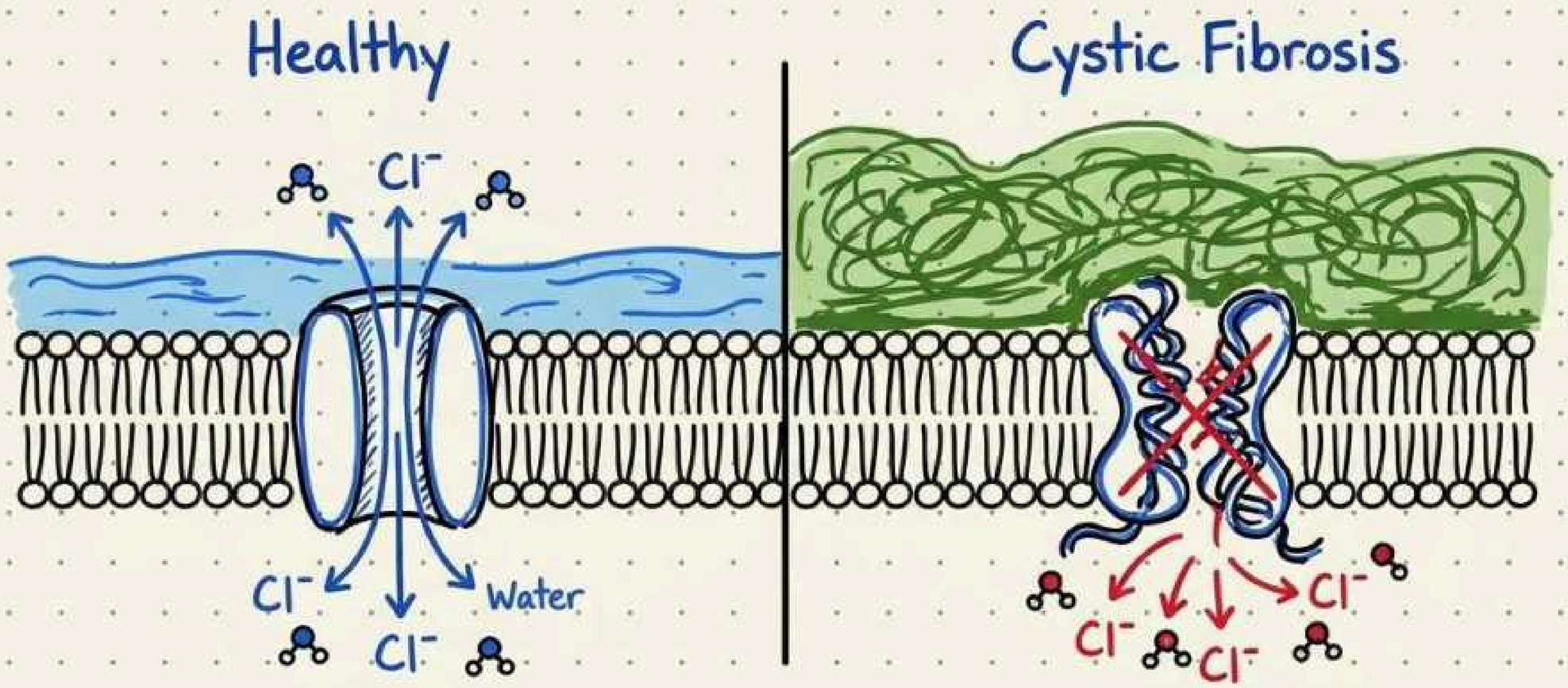


Neurons releasing chemical messengers

Both processes require energy to physically reshape the membrane.

Transport failure causes real disease.

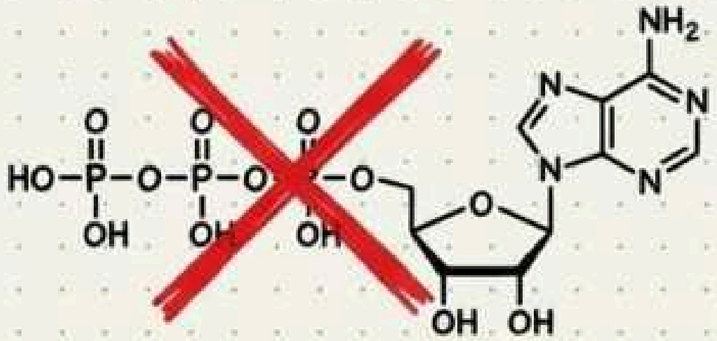
¶ 1.19

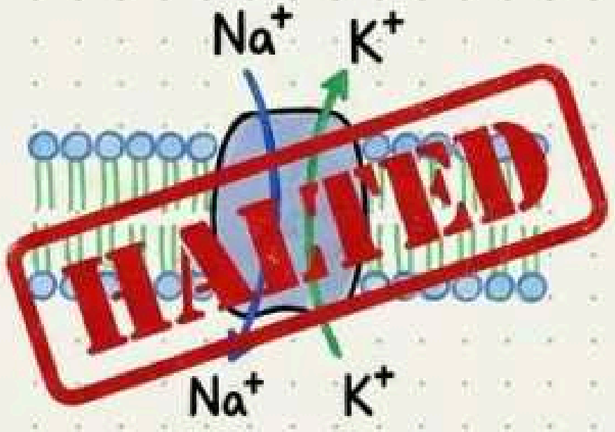


Understanding this faulty chloride channel has led to targeted drugs that force the protein to fold and open. Cell biology turned into medicine.

Takeaway Thought Experiment.

¶ 1.20





Predict the Gradients (Leaks over an hour)...

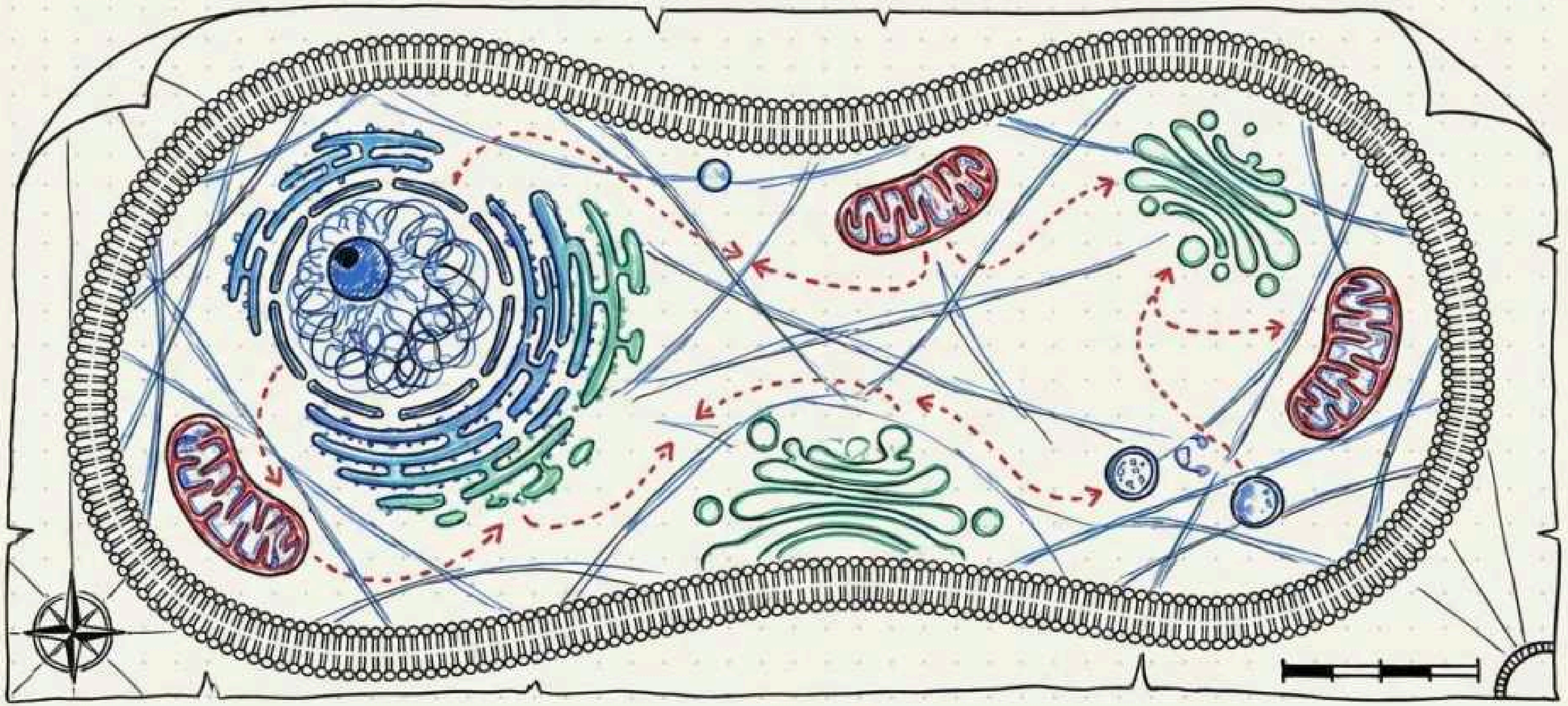
Predict the Voltage (Nernst equilibrium)...

Predict the Water Balance (Osmosis)...

Explain your reasoning step by step, using what you learned about leaks, osmosis, and charge.

Next: Stepping inside the cell.

¶ 1.21



In Lecture 2, we tour the organelles, the traffic between them, and the protein skeleton that holds it all together.