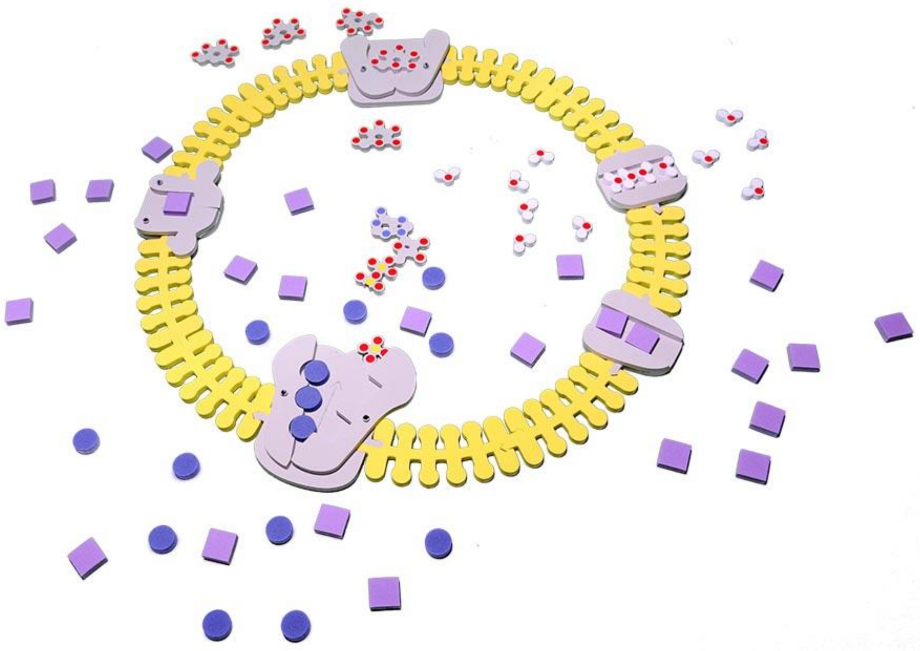


Water water everywhere… but how'd it get in there?

Mark Arnholt

Science Educator

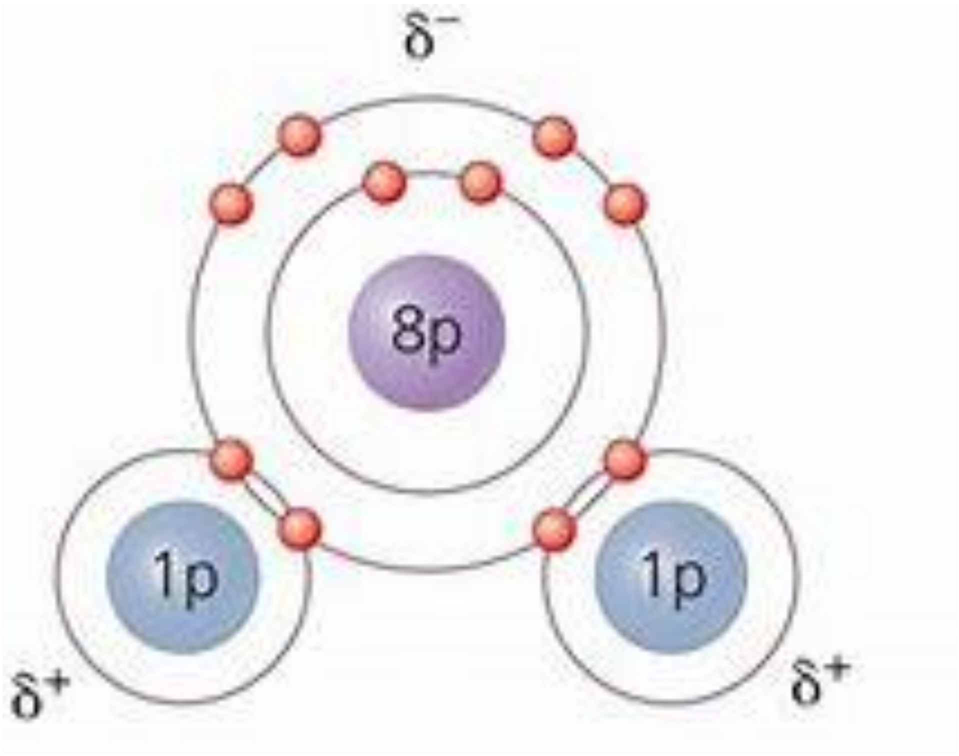
3D Molecular Designs

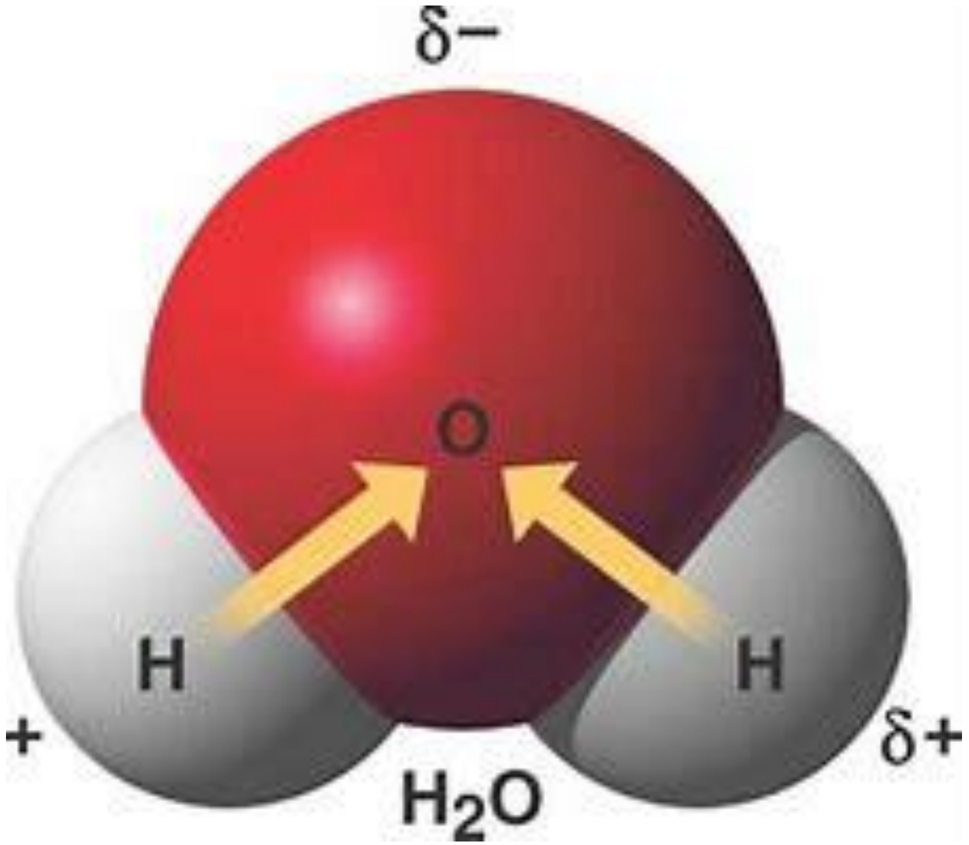
Milwaukee, WI

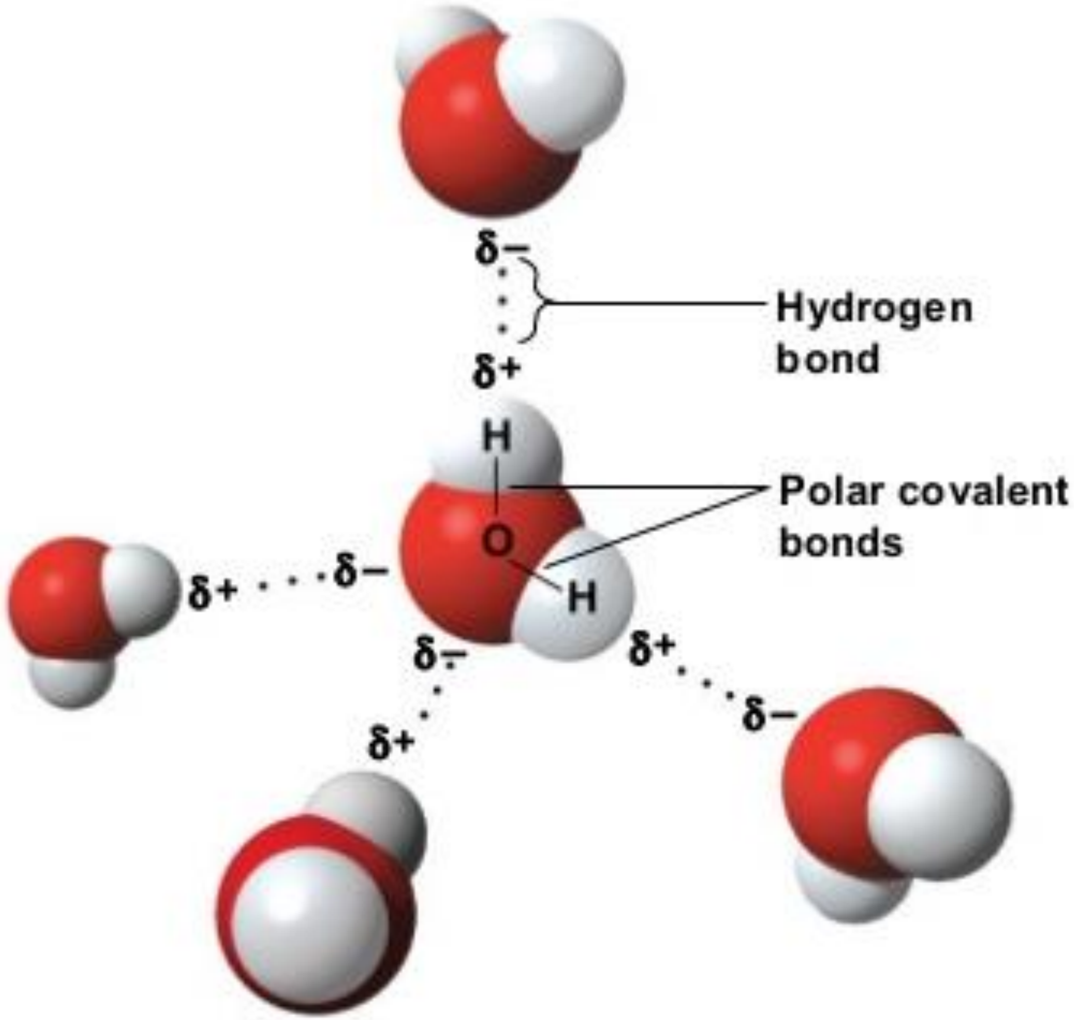
INQUIRE. INSPIRE. TRANSFORM.
CAST23
Presented by STAT SCIENCE TEACHERS ASSOCIATION of TEXAS

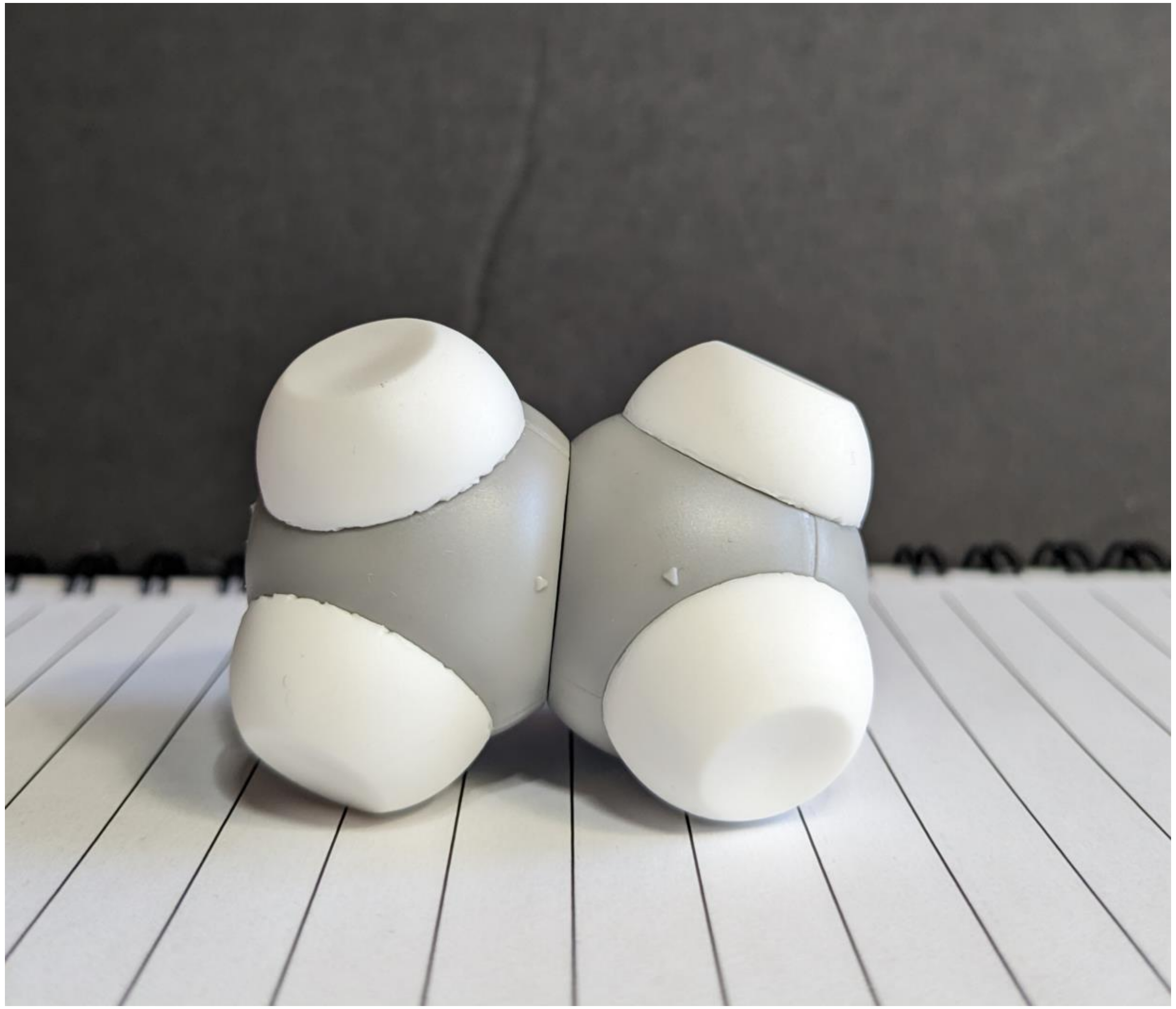
- Find a physical representation of water.
- How do you know which model represents a water molecule?
- What color represents the oxygen?
- Which atoms interact with each other?
- Why do water molecules stick to each other?

Water exhibits POLAR COVALENT bonds






δ–
δ+
Hydrogen
bond
H
O
H
Polar covalent
bonds
δ+
δ–
δ–
δ+
δ+
δ–



What patterns do you see?

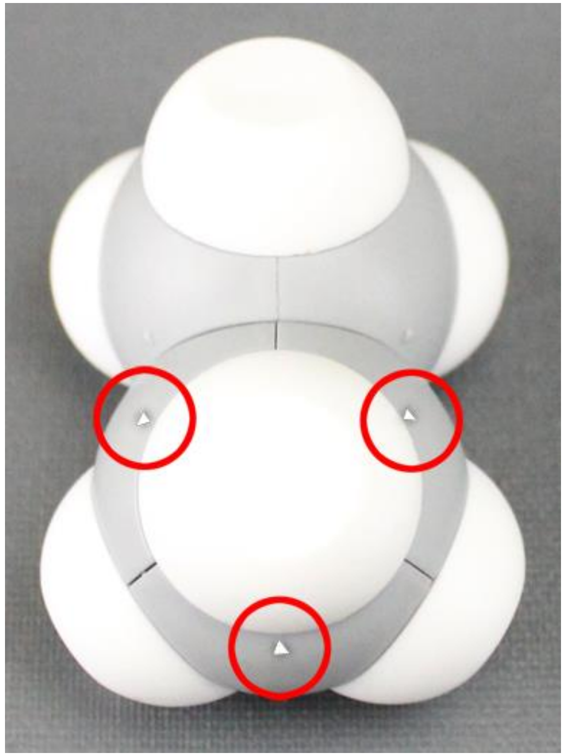
What questions do you have?

How does this molecule interact with water molecules ?

What patterns do you see?

What questions do you have?

A closer look at solubility

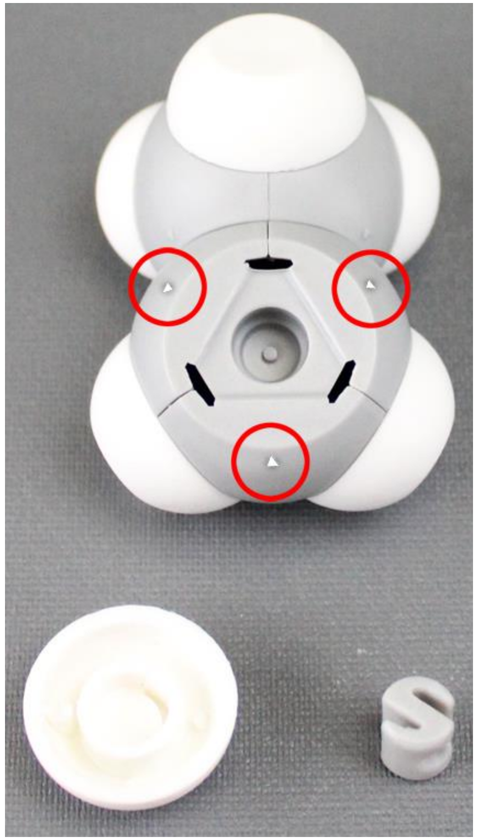


Molecular Manipulation

A closer look at solubility

Remove a hydrogen

Add a hydroxide

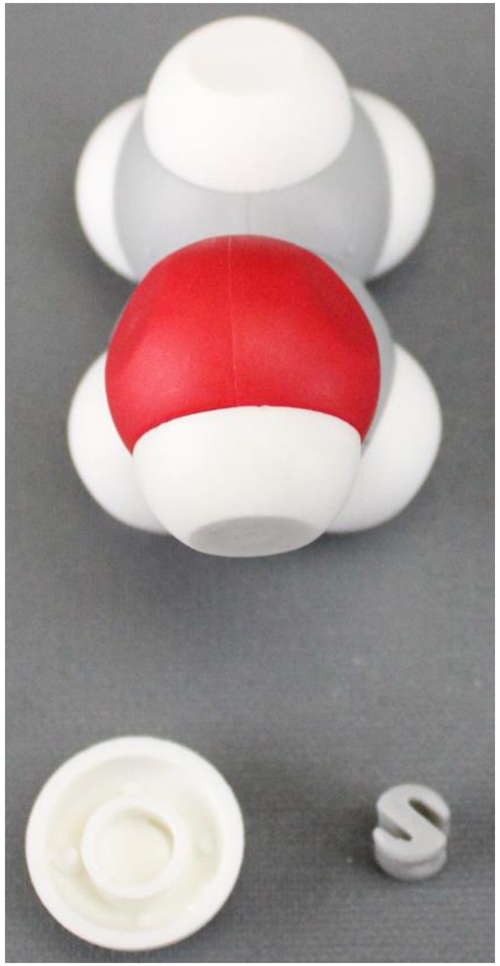


How does this molecule interact with water molecules ?

What patterns do you see?

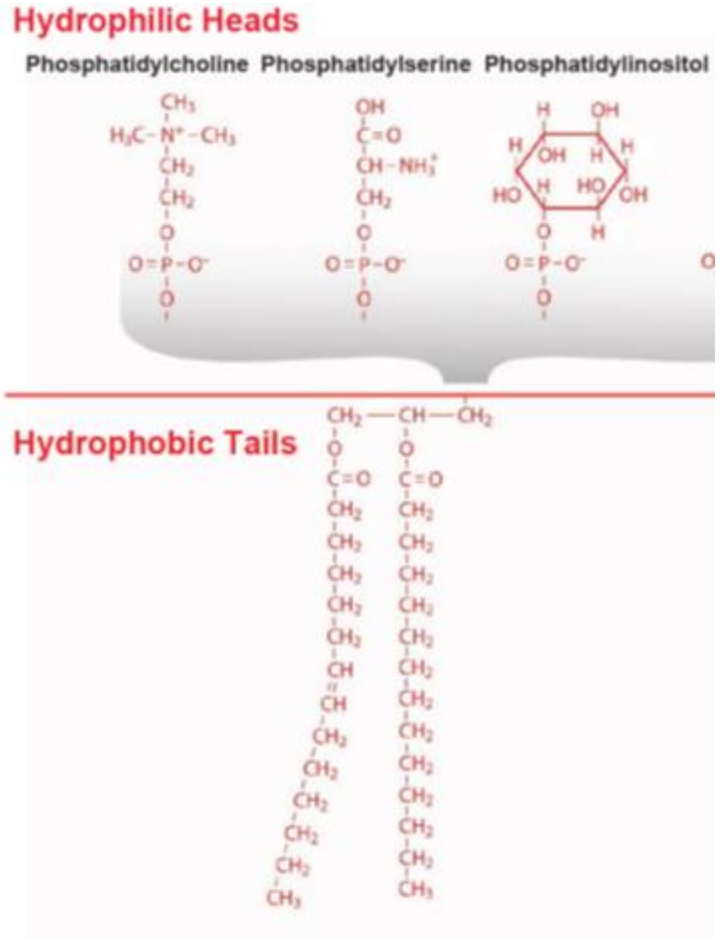
What questions do you have?

A closer look at solubility



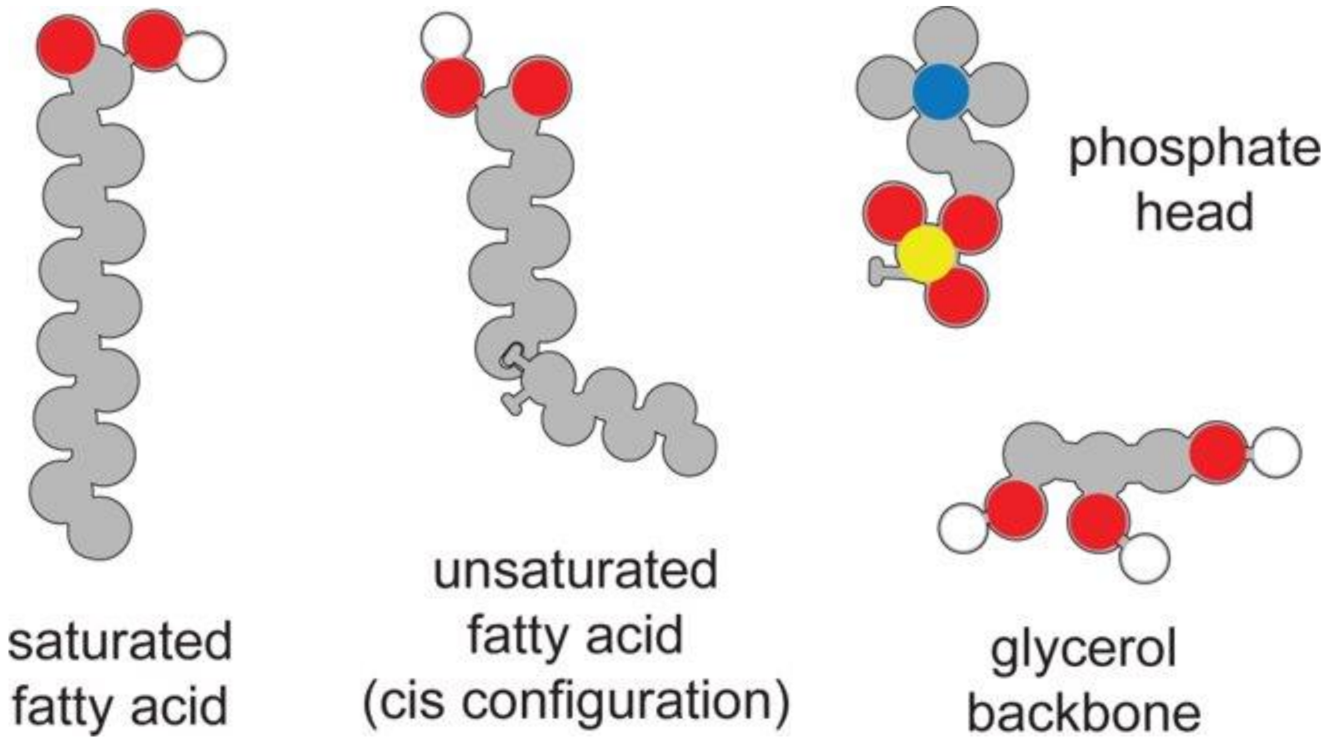
What about a phospholipid?
What do you notice?

Modeling the Membrane: Phospholipids

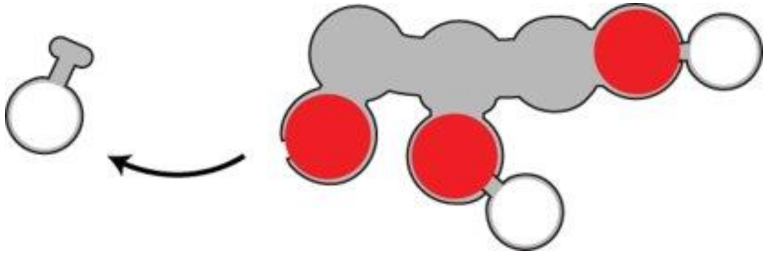


Using multiple models help explain nuance in the phenomena we are typing to explain.

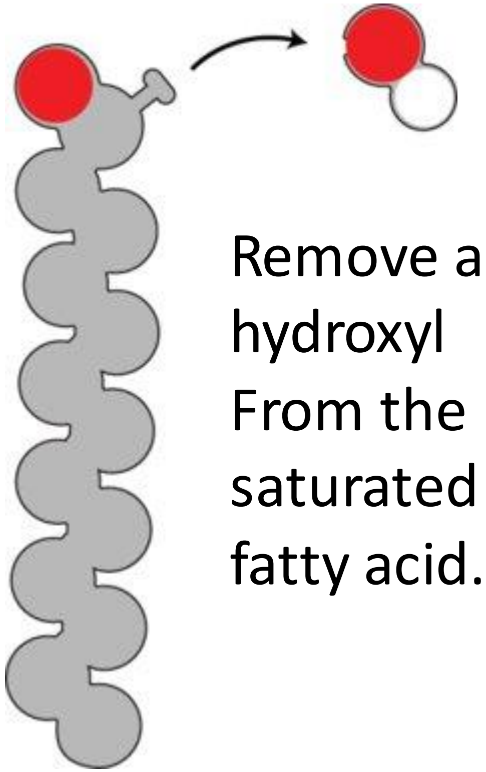
Constructing A Phospholipid



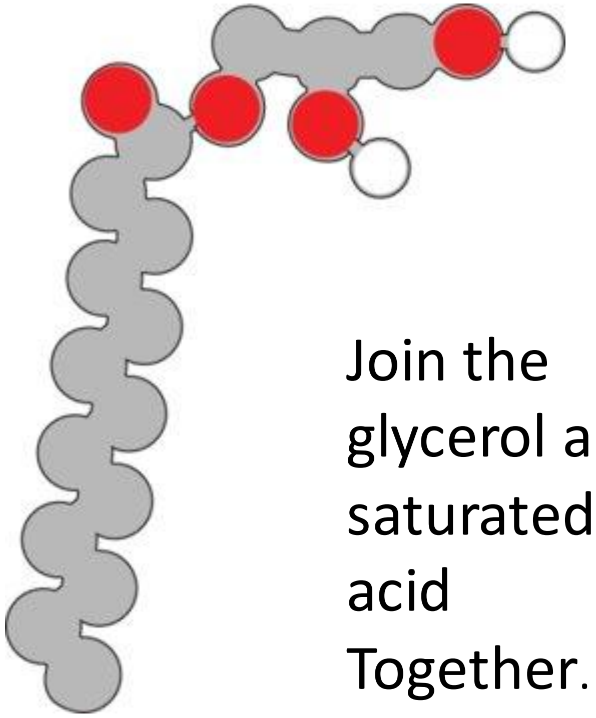
Constructing A Phospholipid



Remove a hydrogen from the glycerol backbone.

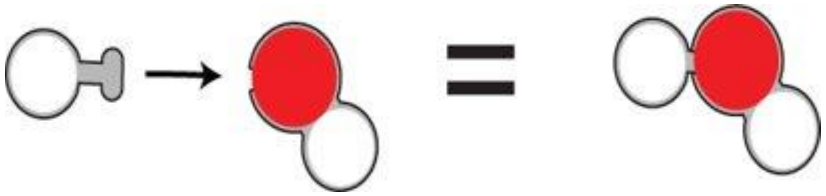


Remove a hydroxyl From the saturated fatty acid.

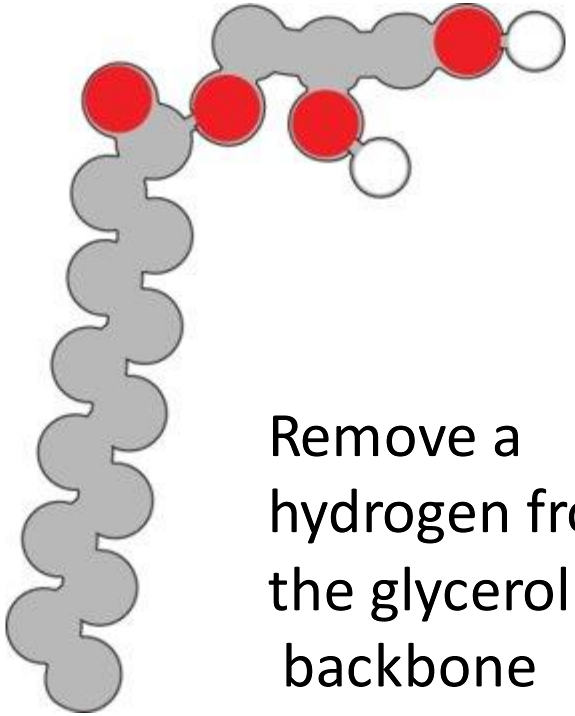


Join the glycerol and saturated fatty acid Together.

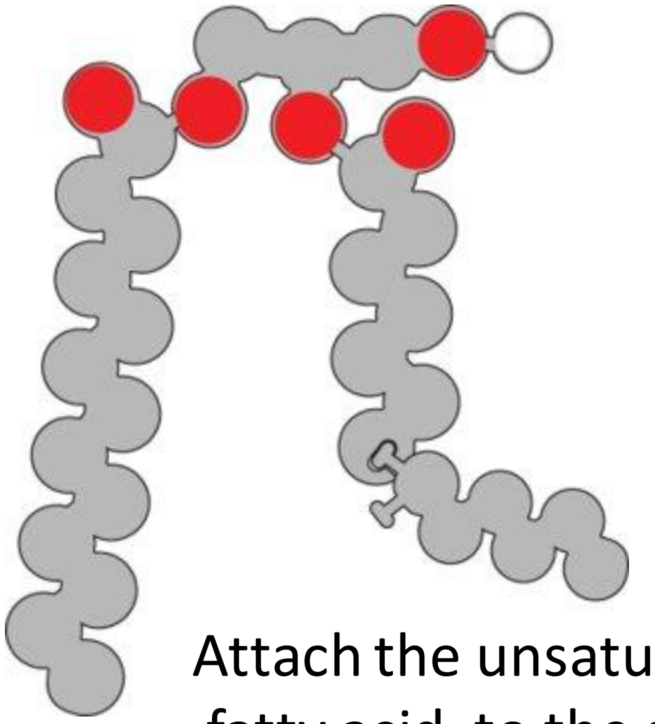
Constructing A Phospholipid



Join the hydrogen and the hydroxyl group to make water.



Remove a hydrogen from the glycerol backbone

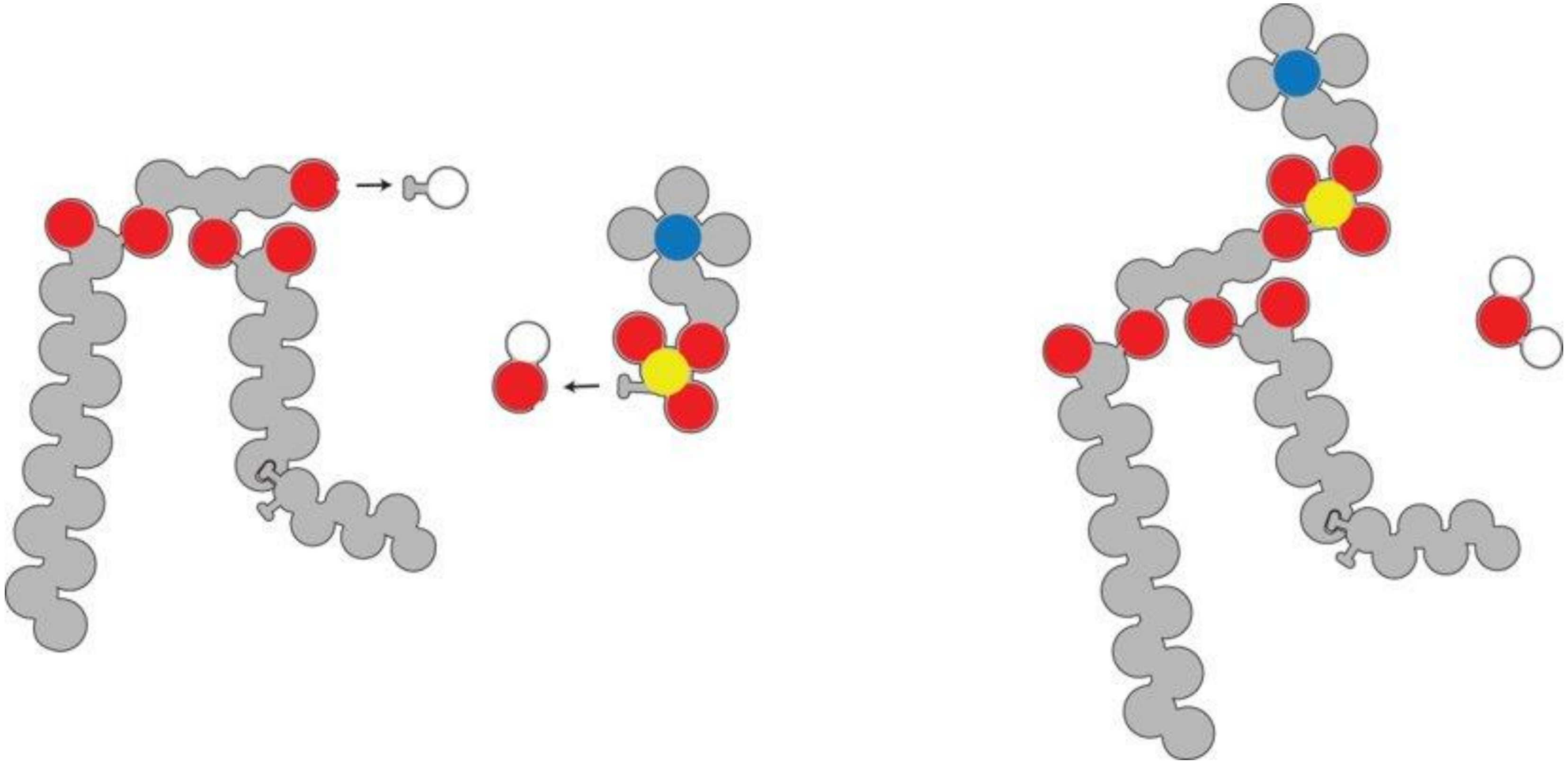


Attach the unsaturated fatty acid to the glycerol backbone

Constructing A Phospholipid

Remove a hydrogen from the glycerol backbone and attach the phosphate head.

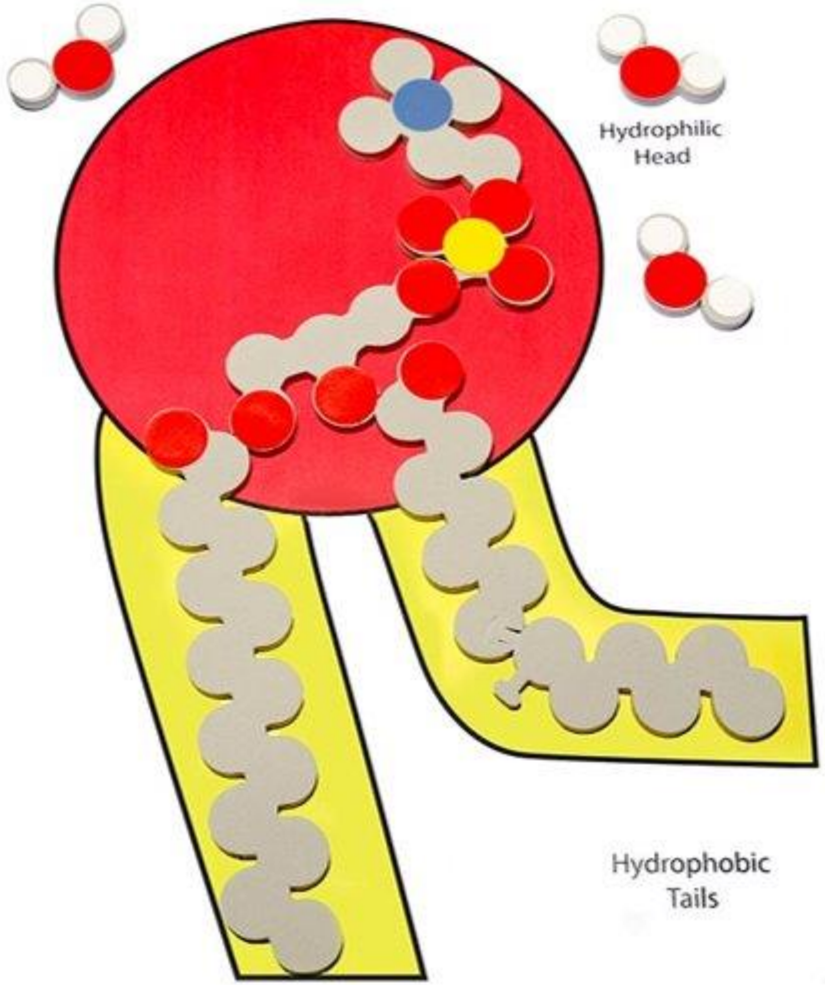
Join the hydrogen with a hydroxyl group to make water.



Constructing A Phospholipid

How are the models different?

Why is it important to use multiple models to represent the same structure?

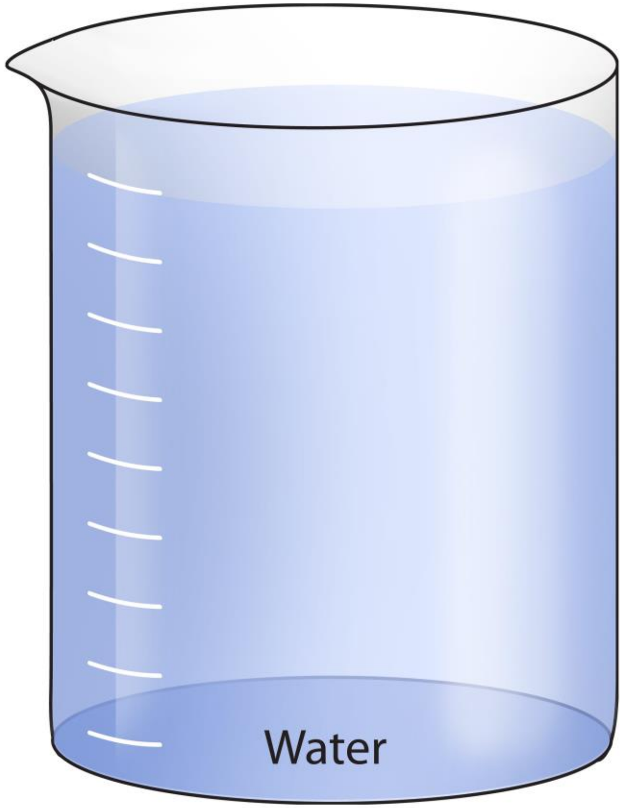


Building a Cell Membrane

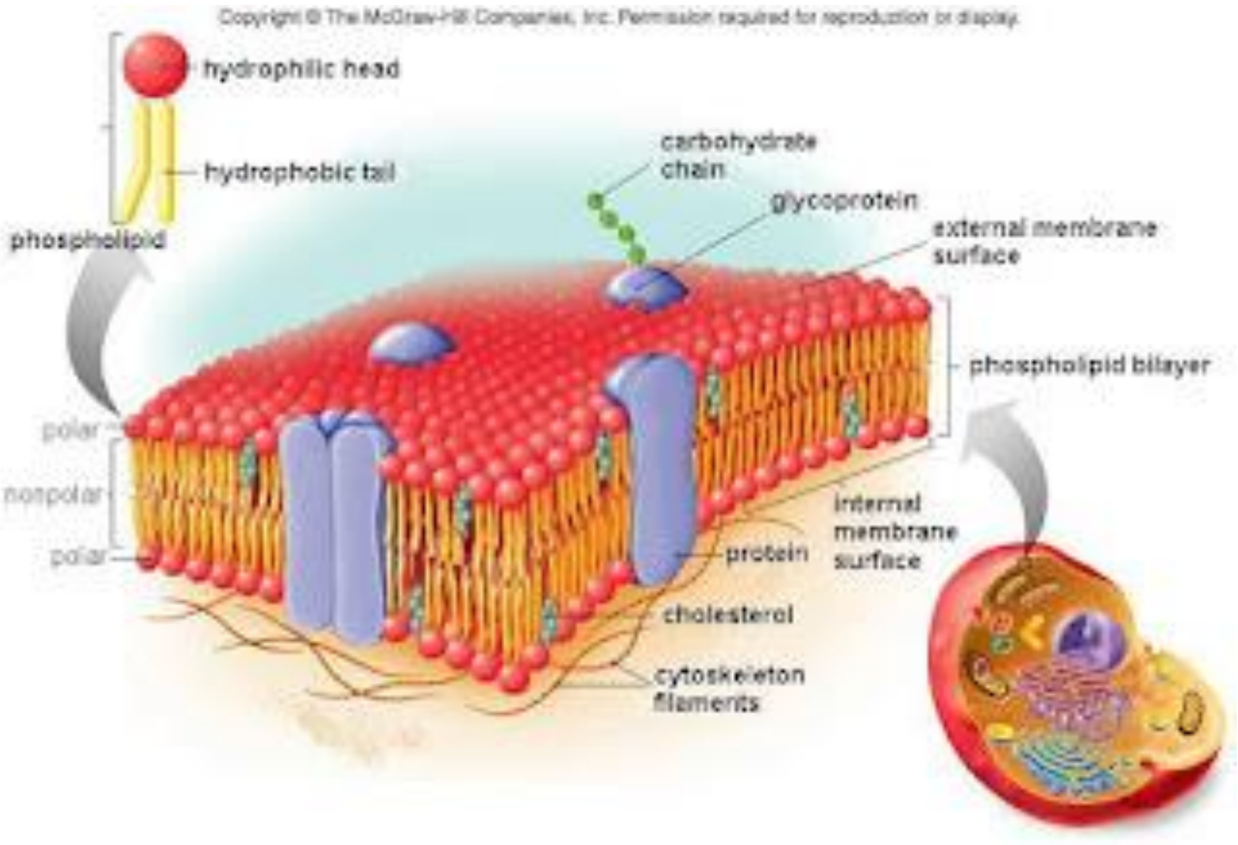
How would ten phospholipids arrange to form a film on water?

How would ten phospholipids arrange to be submerged in a beaker of water?

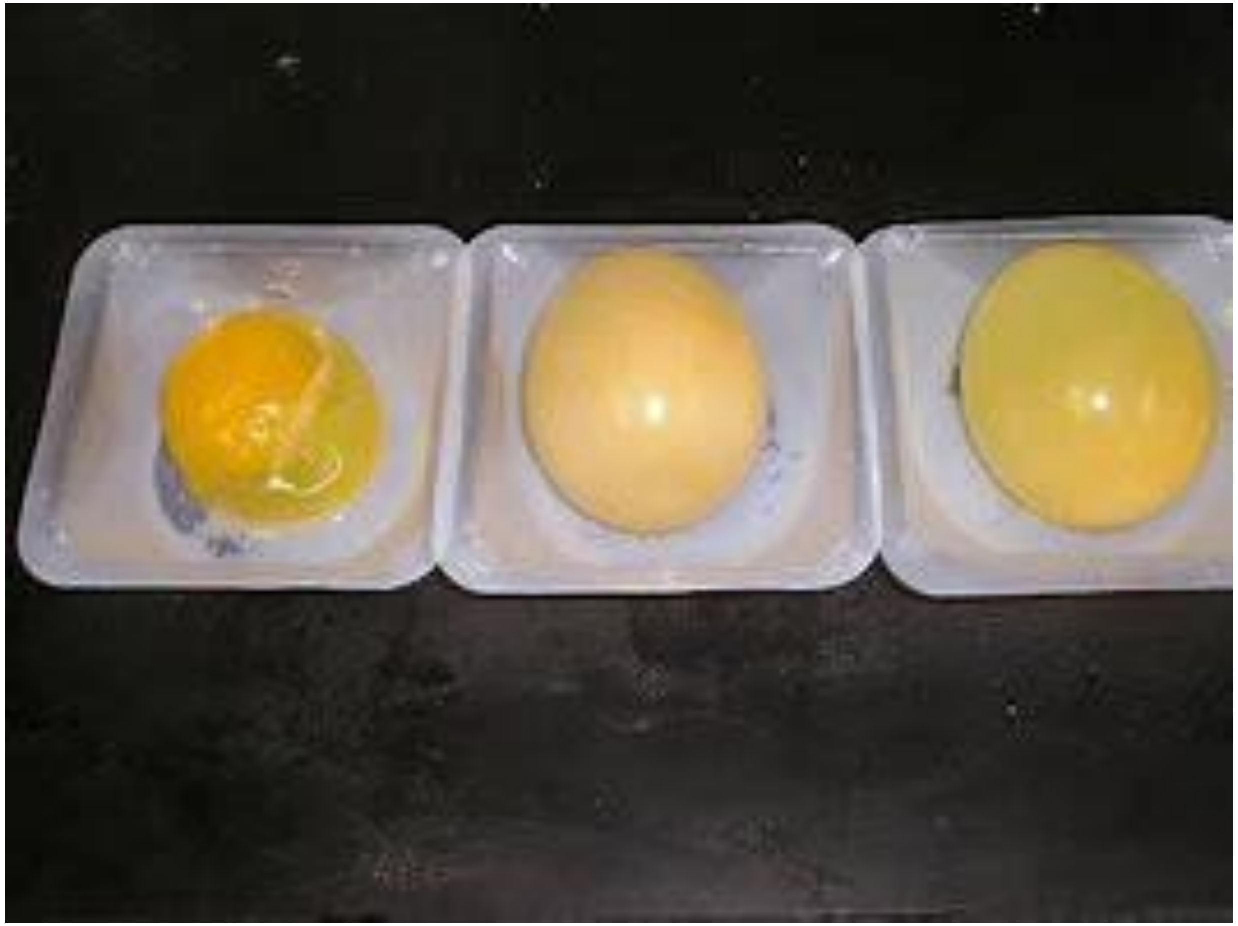
How would phospholipids be arranged to be both submerged and contain water.

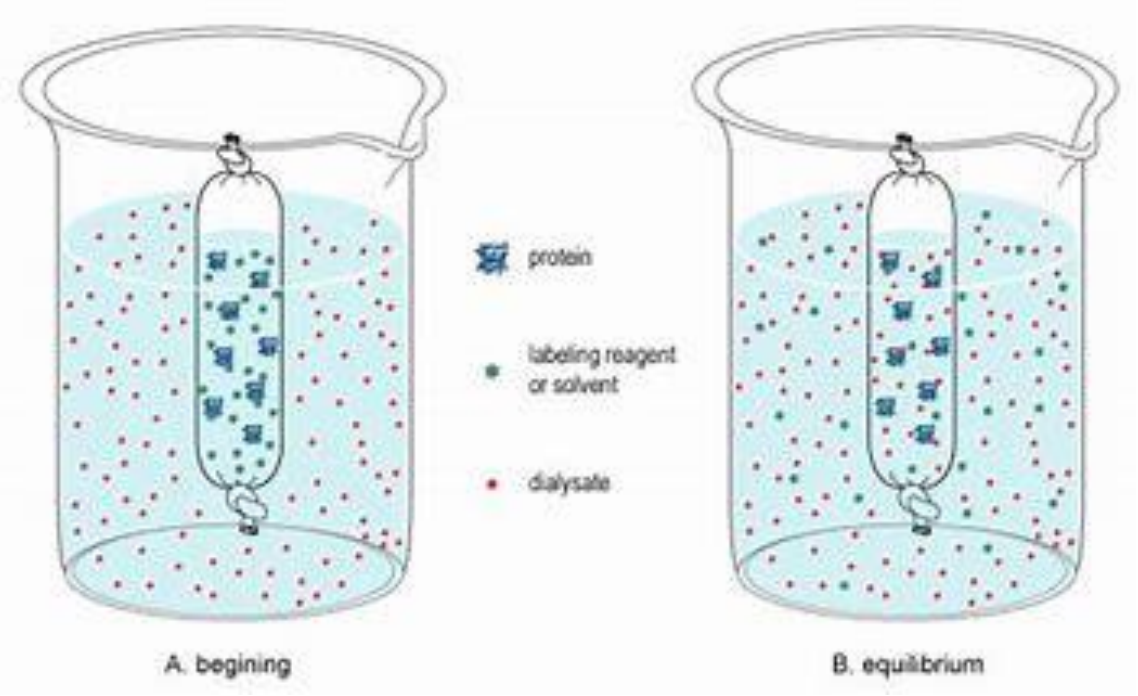


The Cell Membrane



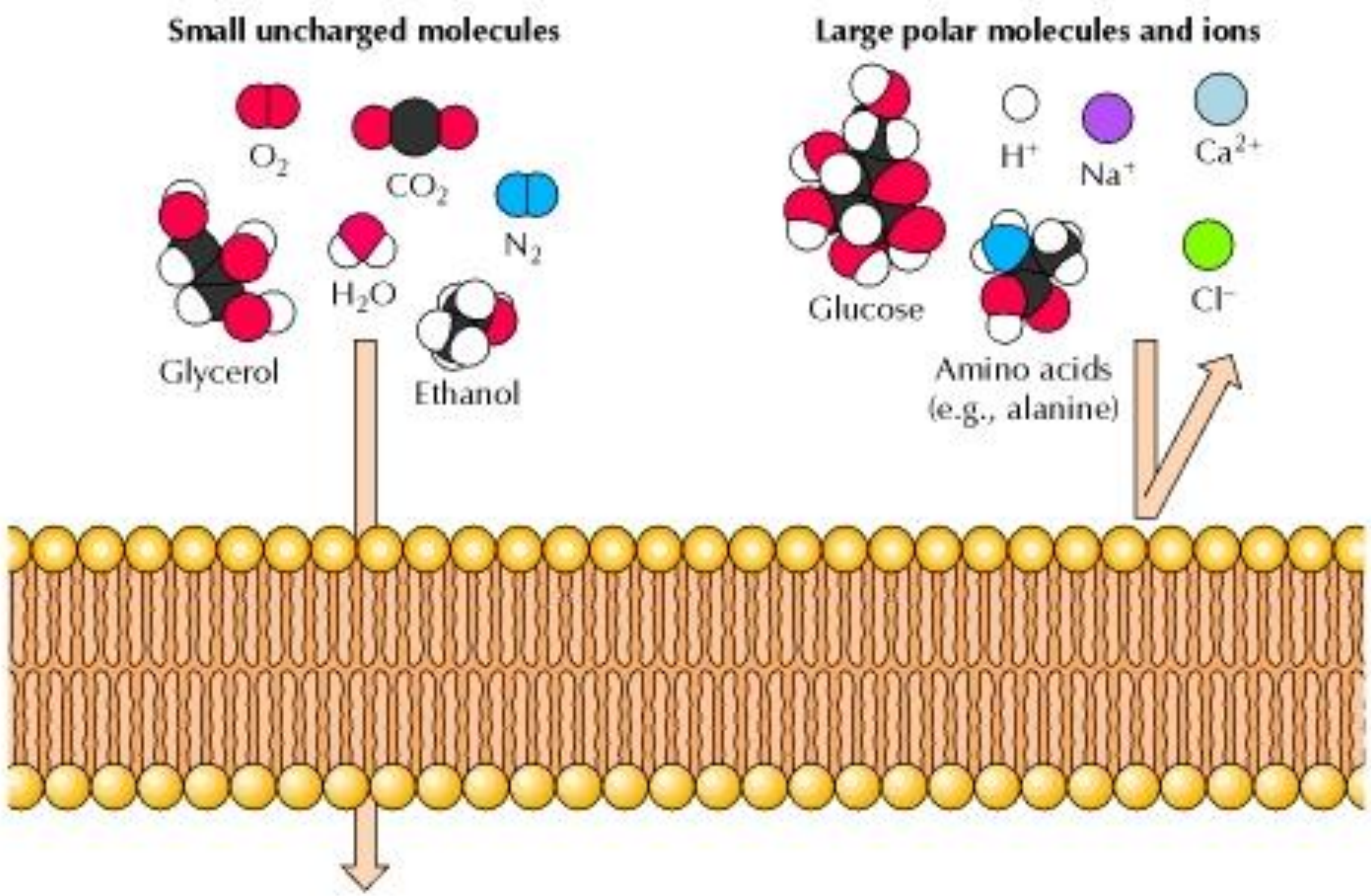
… and then we have our class do a cellular model wet lab





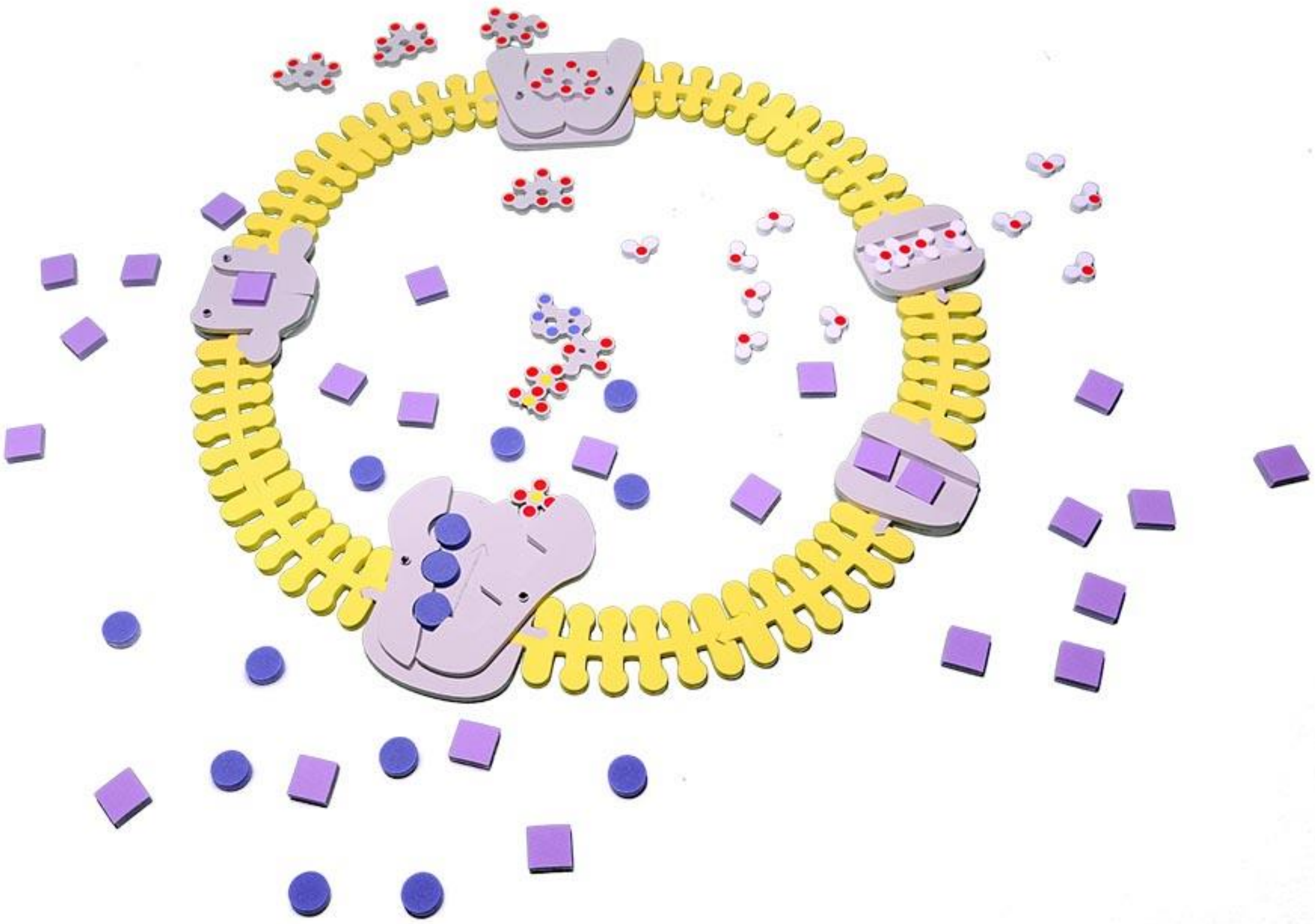
Hold on a second

The problem…

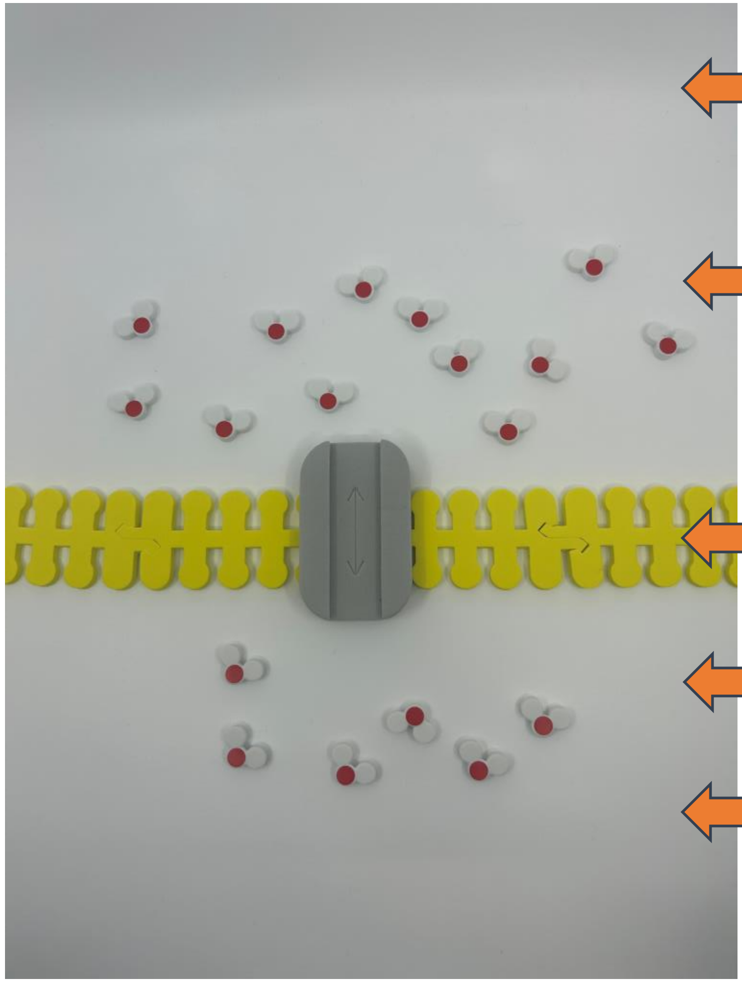


Small uncharged molecules
O_2
CO_2
N_2
H_2O
Glycerol
Ethanol
Large polar molecules and ions
Glucose
H^+
Na^+
Ca^{2+}
Cl^-
Amino acids
(e.g., alanine)

There’s a lot going on here, so let’s simplify it!



Let's focus on water first – Add the following



Extracellular – Outside of the cell

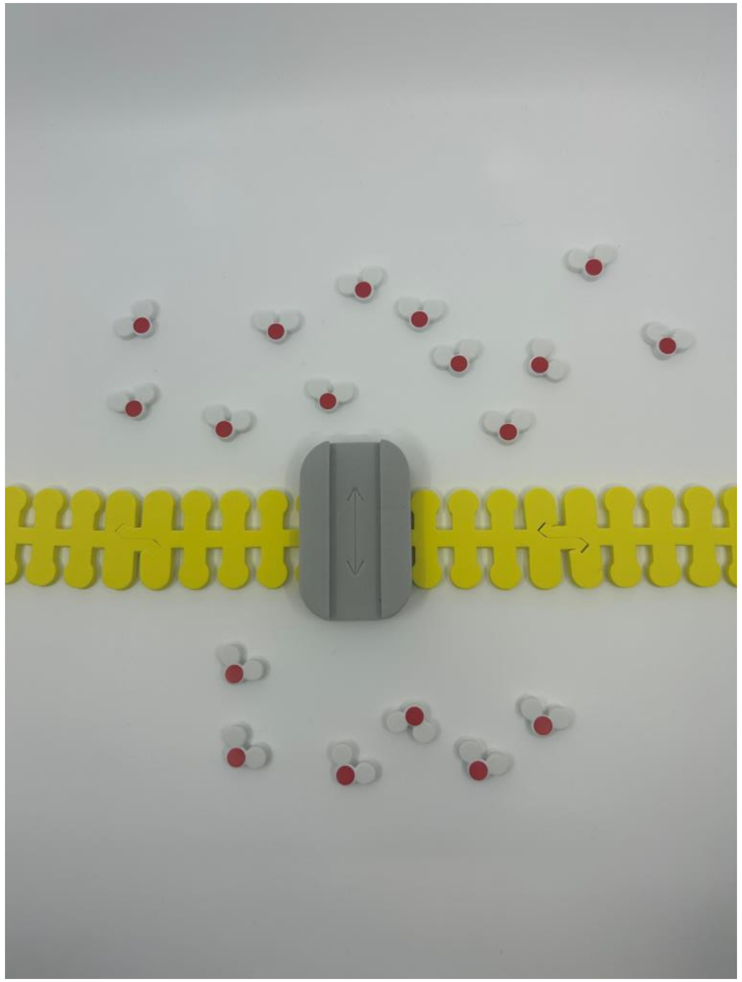
12 water molecules

Aquaporin and cell membrane

6 water molecules

Intracellular – Inside of the cell

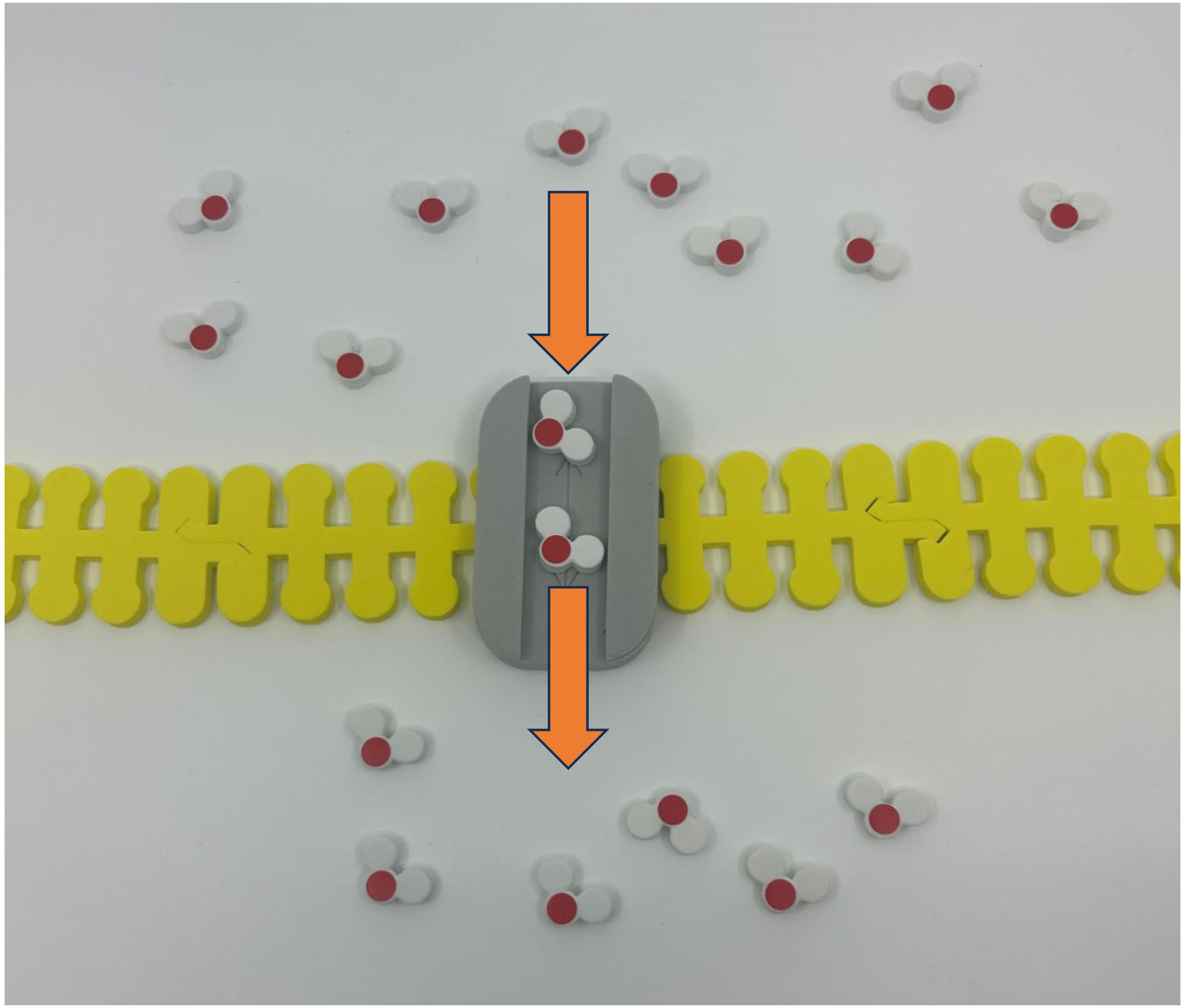
With an aquaporin in place…



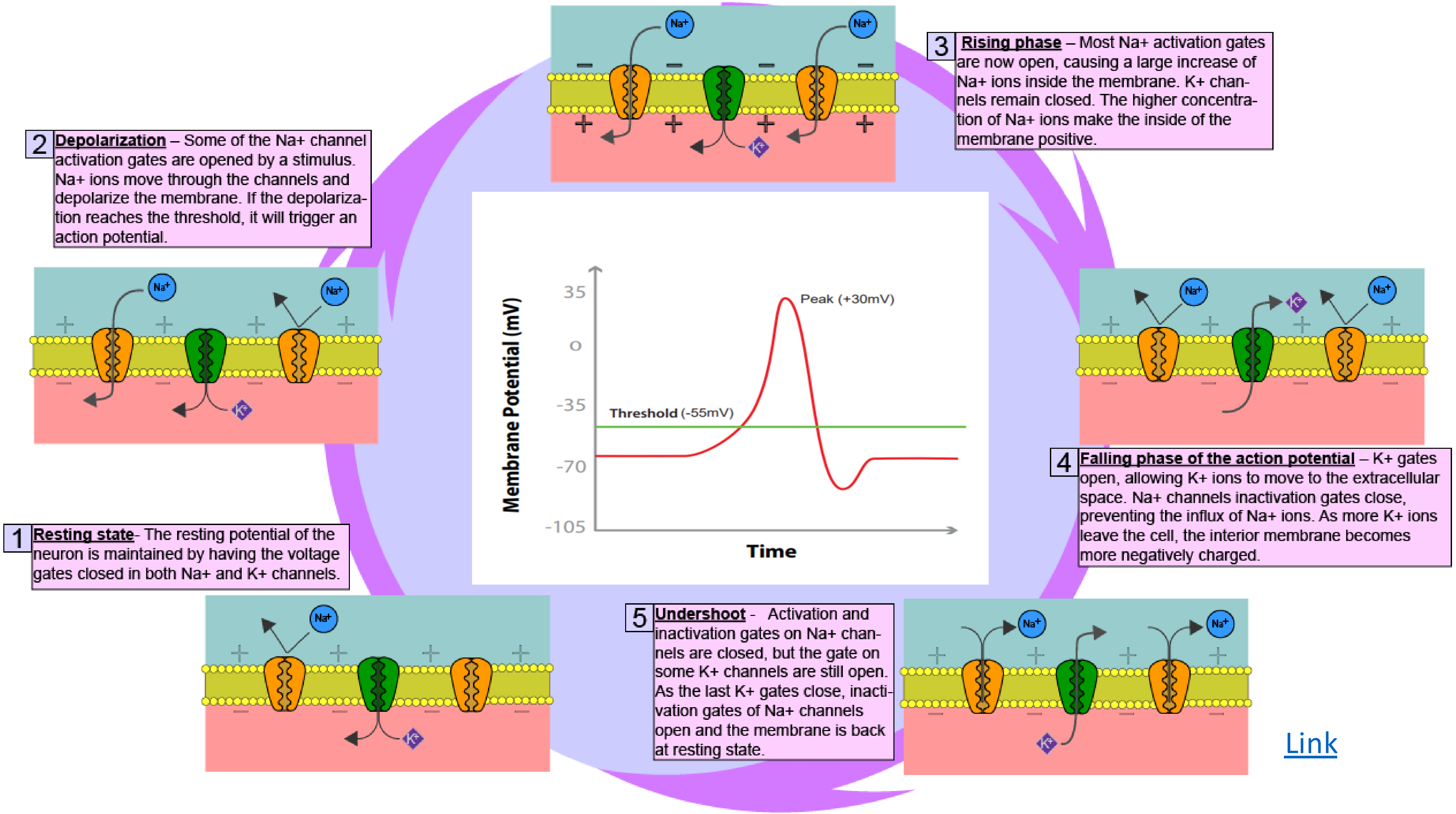
Based on what you know about water potential and osmosis, in which direction would the water molecules move?

How many water molecules should you move?

Move 3 water molecules across to reach equilibrium

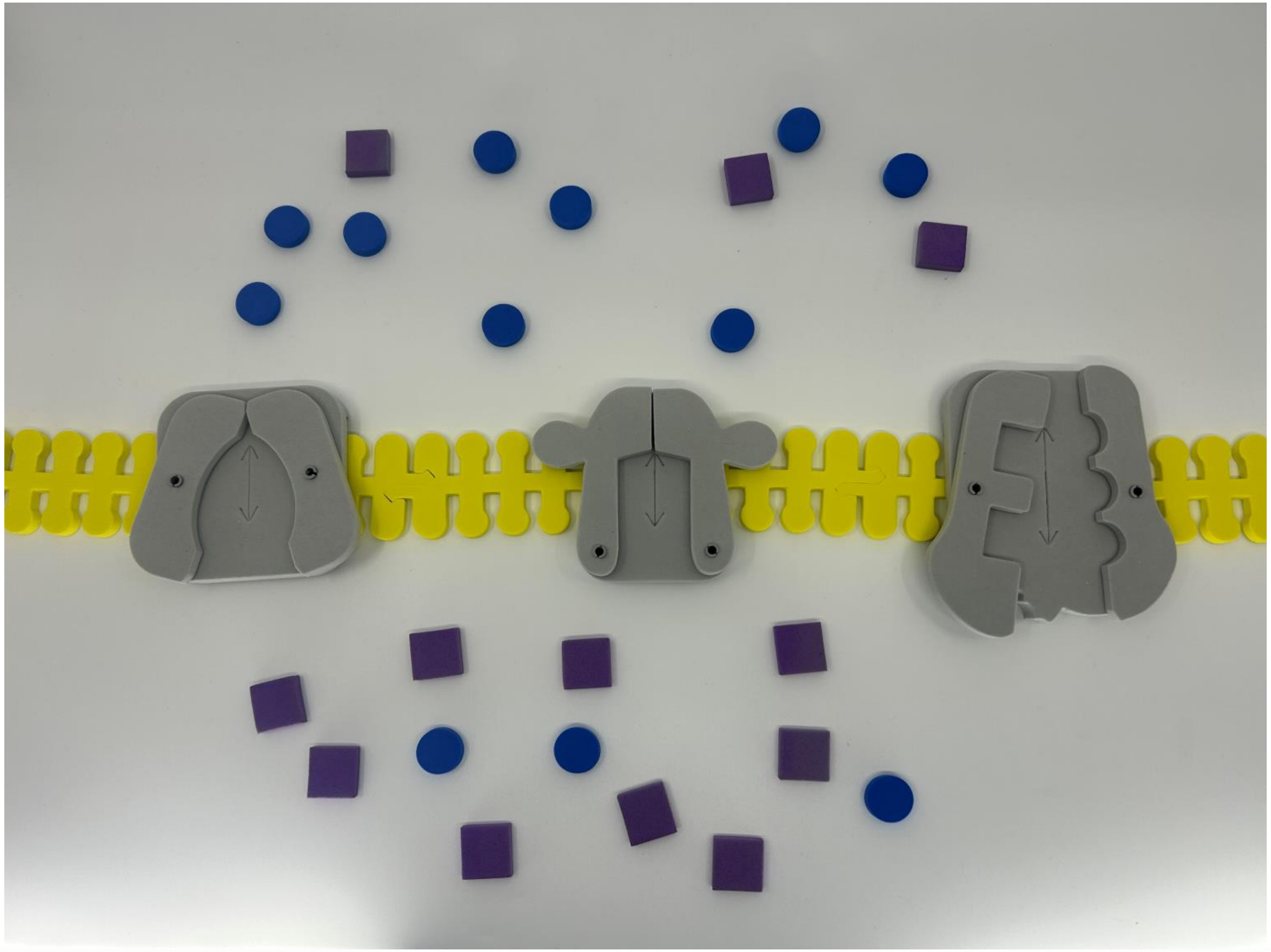


Life is complicated…

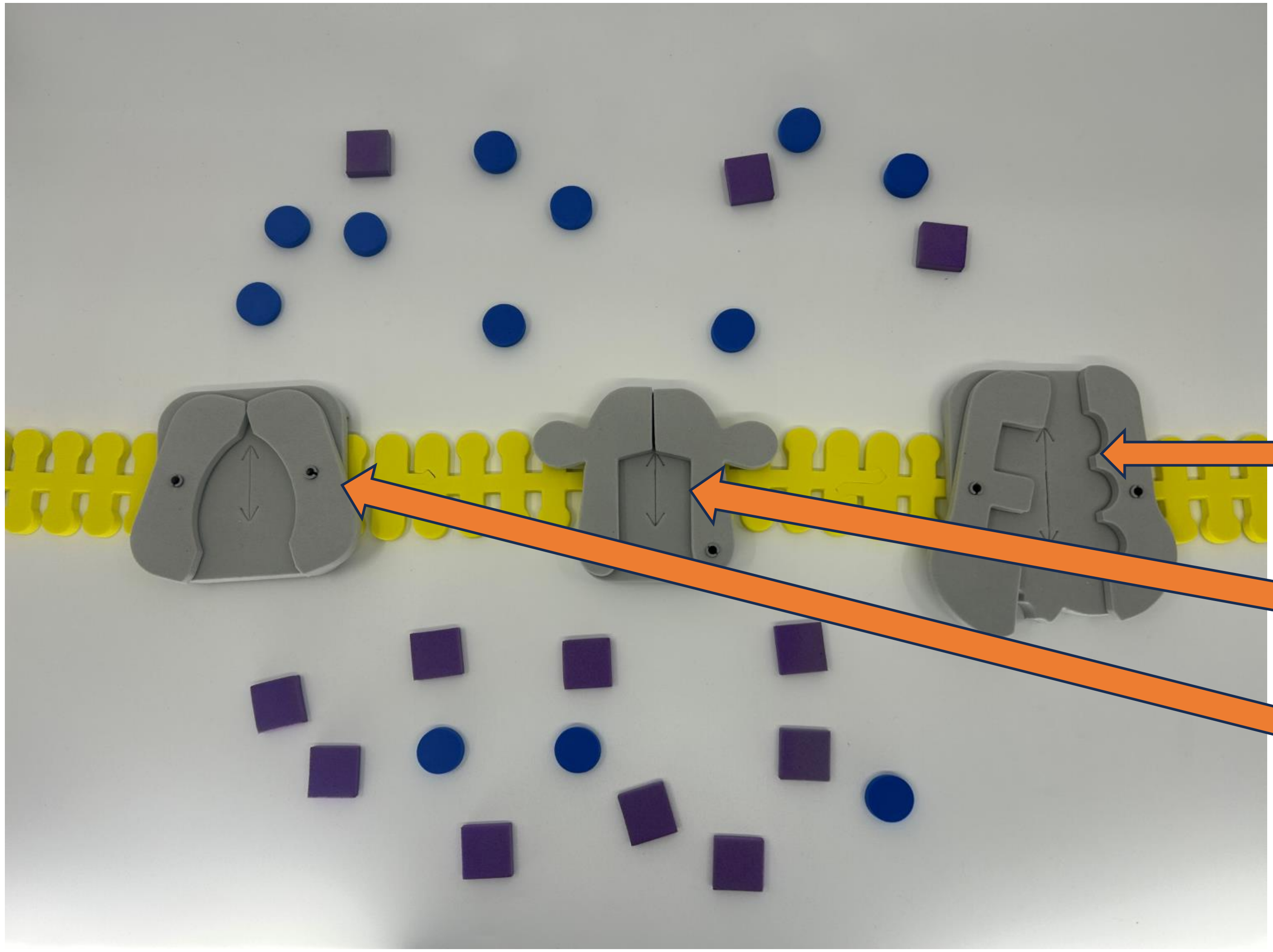


Link

Let’s model an action potential



Let's identify everything



Na+ (x 12)

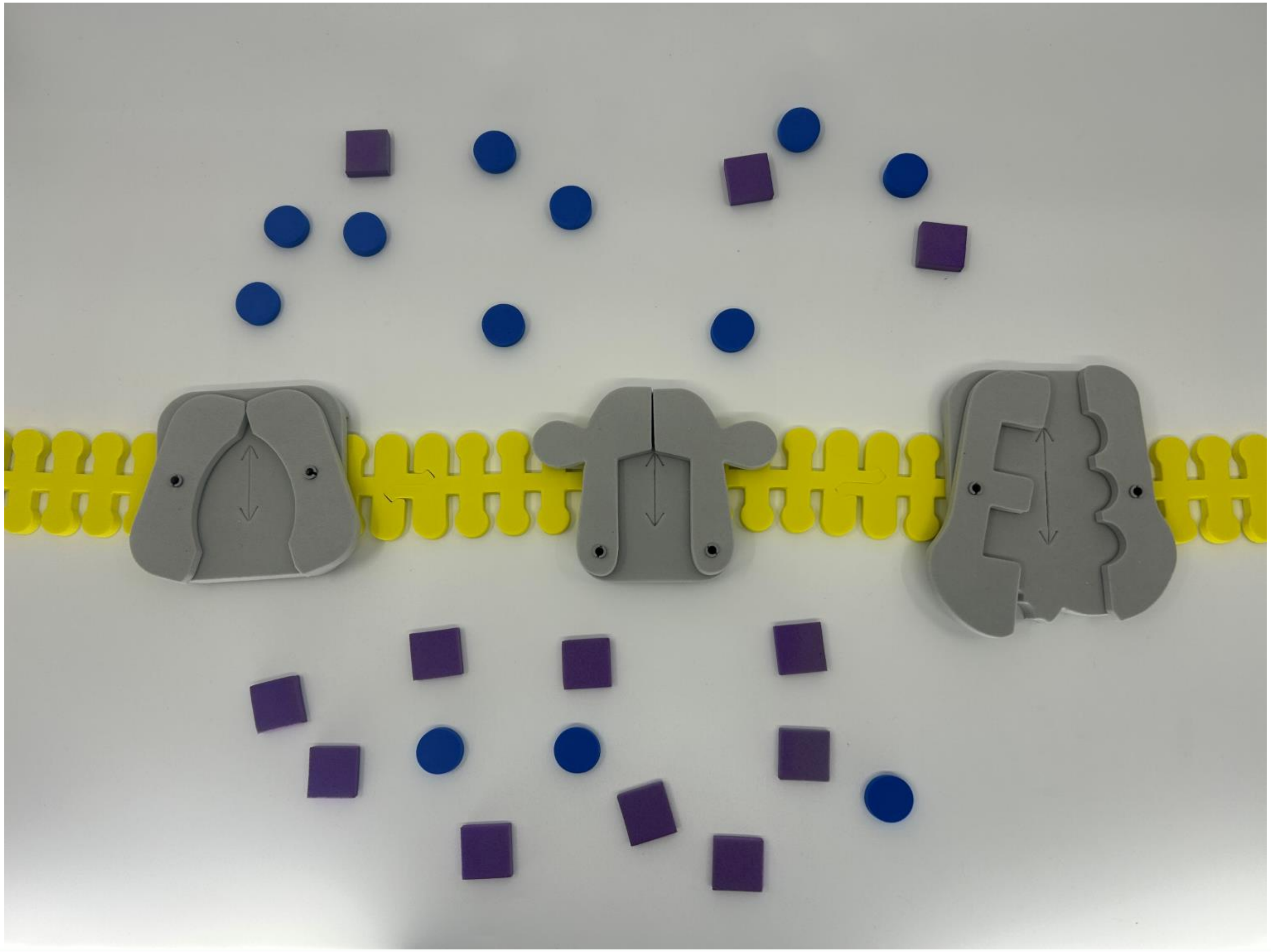
K+ (x 12)

Na+ / K+ Channel

Gated Na+ channel (Simulated)

Gated K+ Channel

What do you notice?



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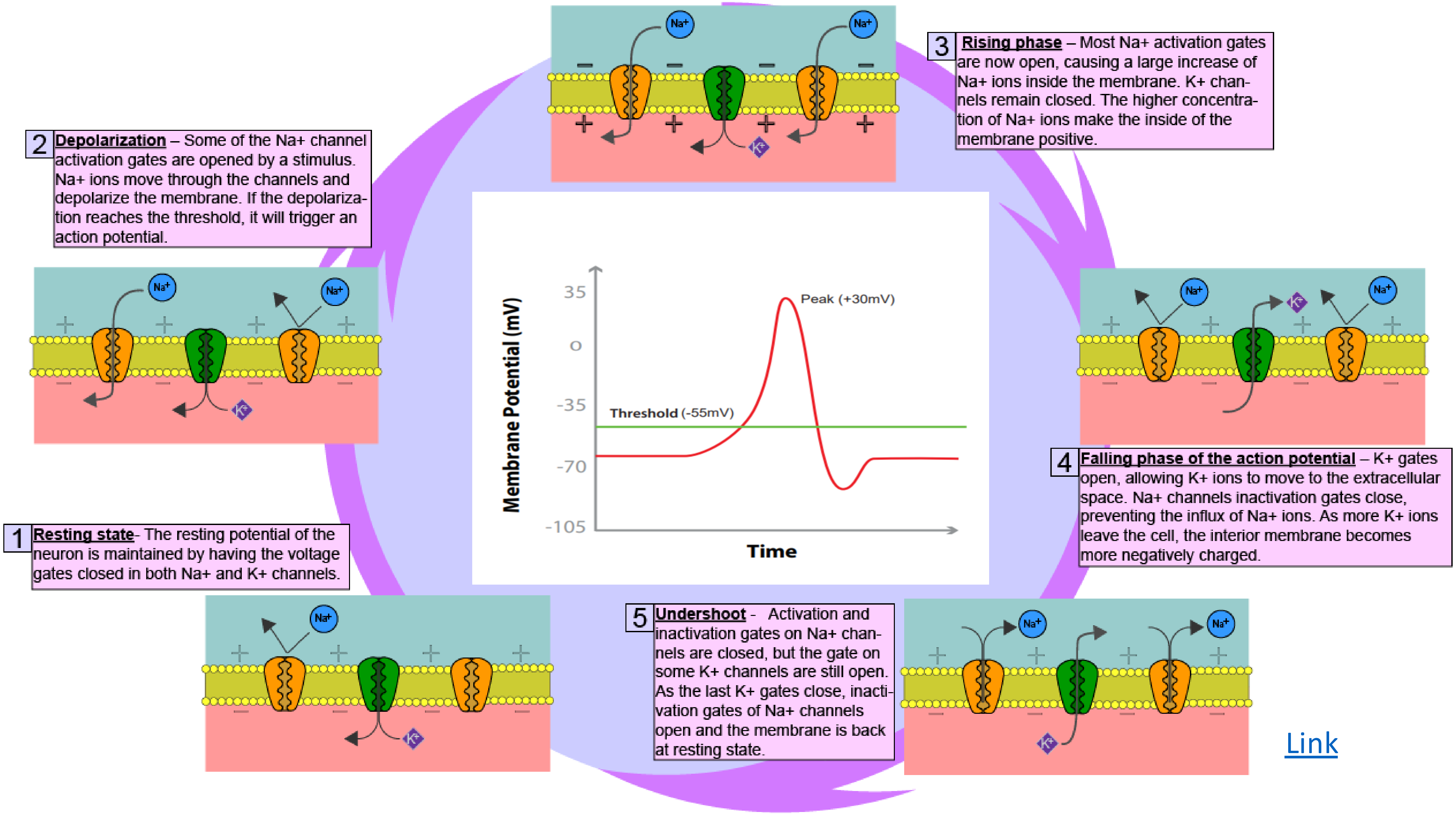
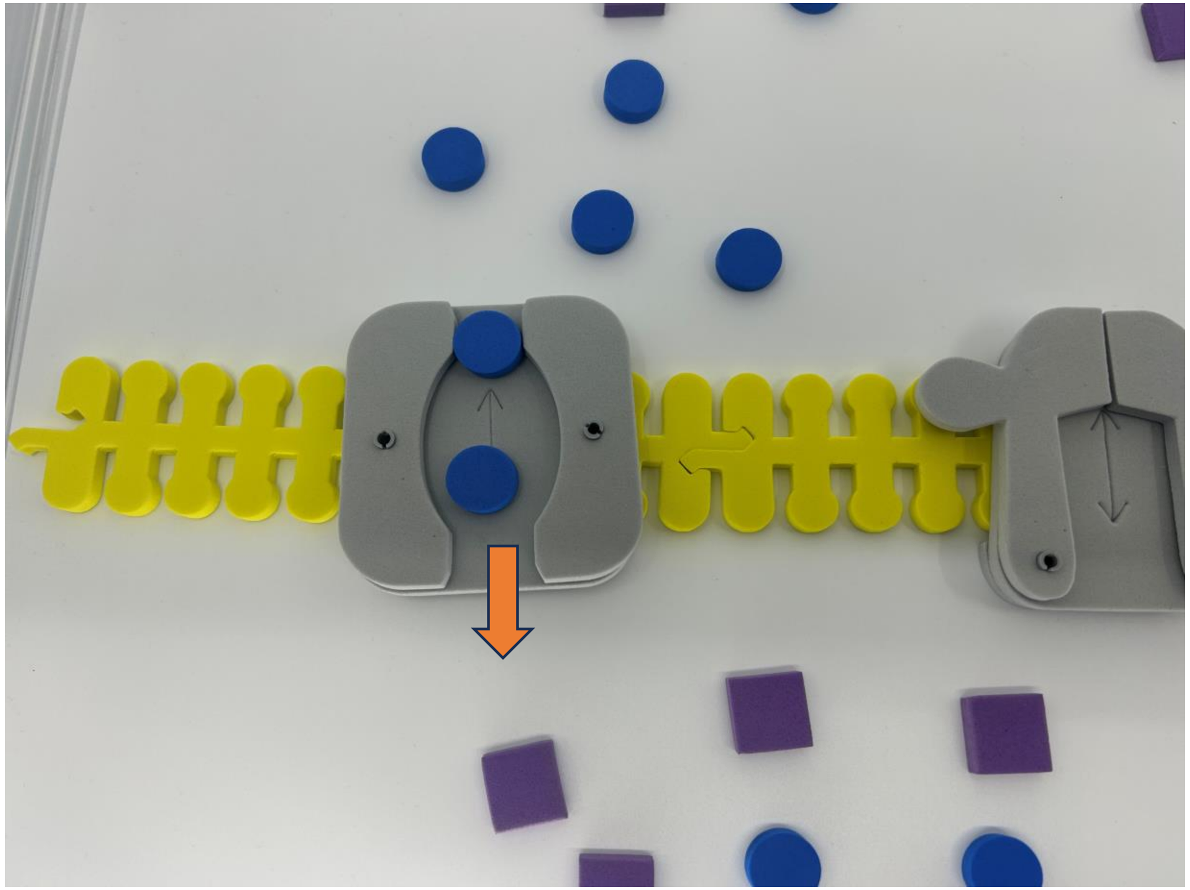
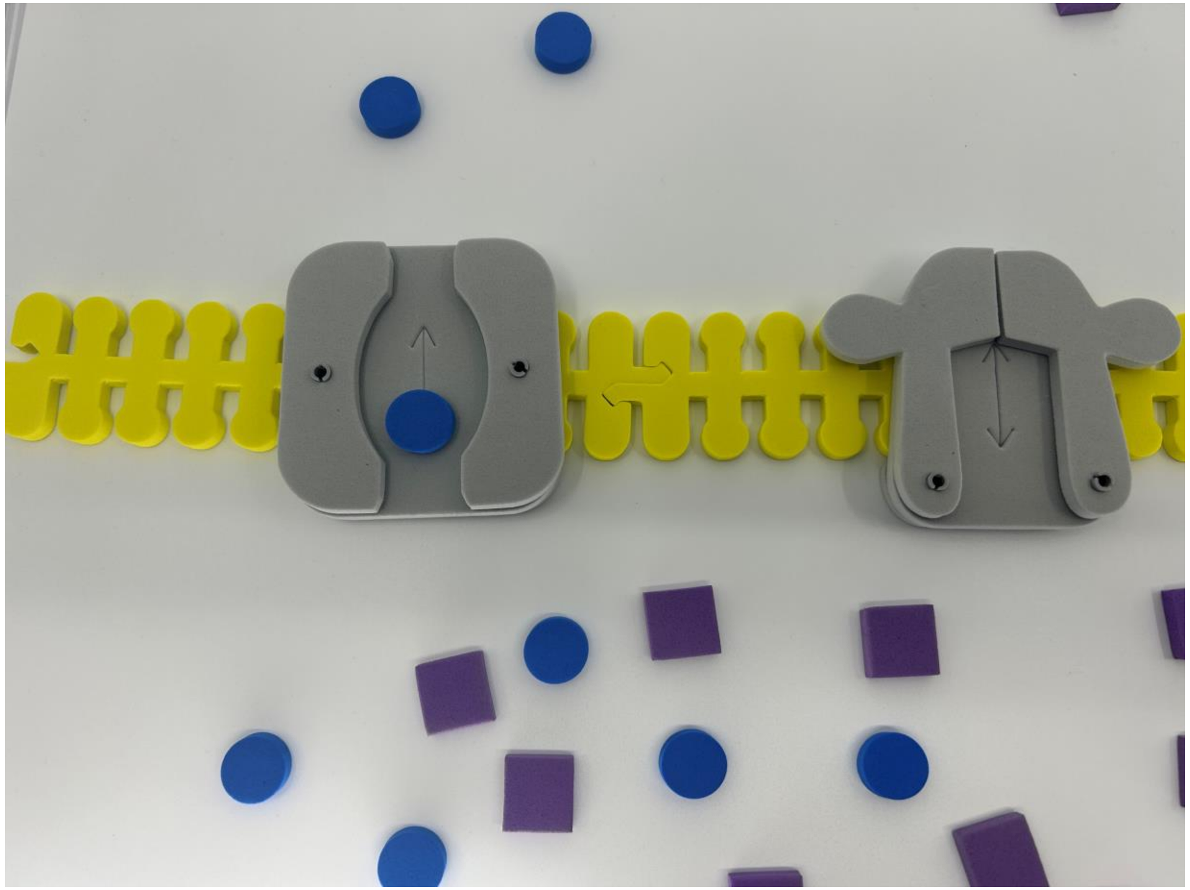


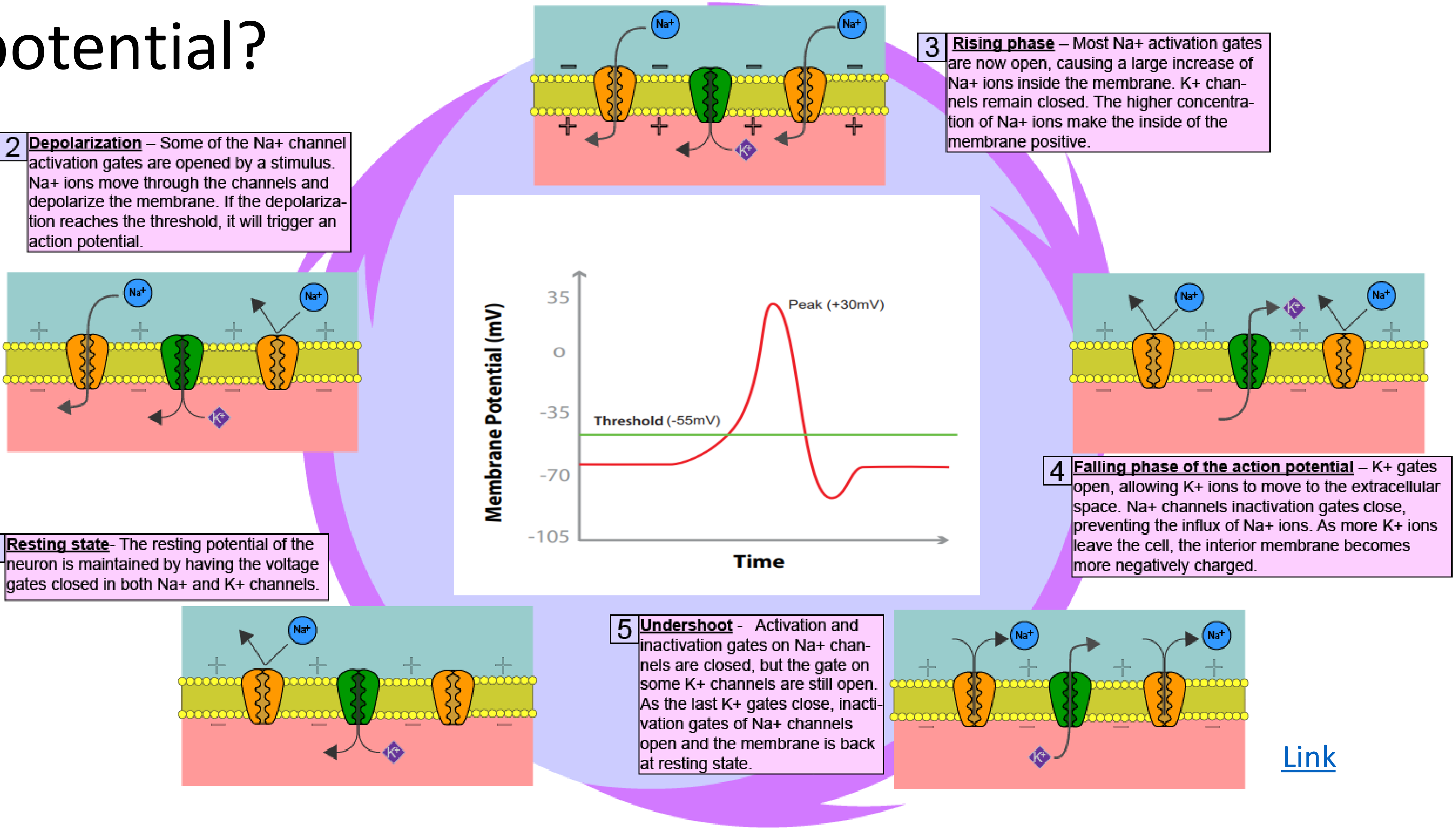
Link

Sodium (Na+) first…





What happens to the membrane potential?



1 **Resting state**- The resting potential of the neuron is maintained by having the voltage gates closed in both Na+ and K+ channels.

2 **Depolarization** – Some of the Na+ channel activation gates are opened by a stimulus. Na+ ions move through the channels and depolarize the membrane. If the depolarization reaches the threshold, it will trigger an action potential.

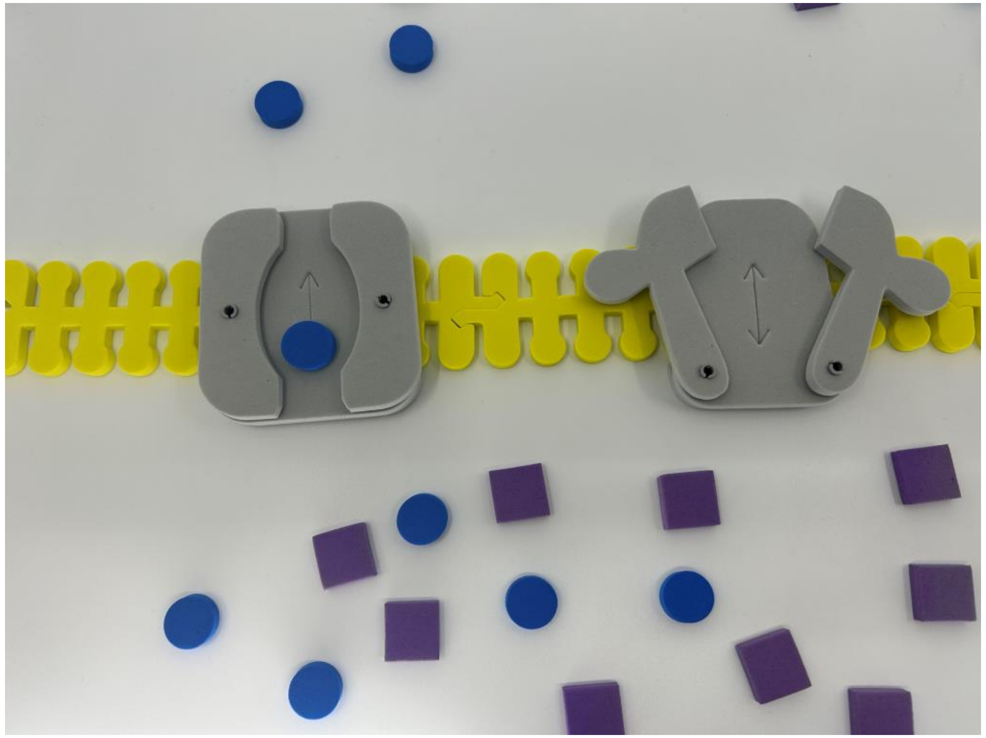
3 **Rising phase** – Most Na+ activation gates are now open, causing a large increase of Na+ ions inside the membrane. K+ channels remain closed. The higher concentration of Na+ ions make the inside of the membrane positive.

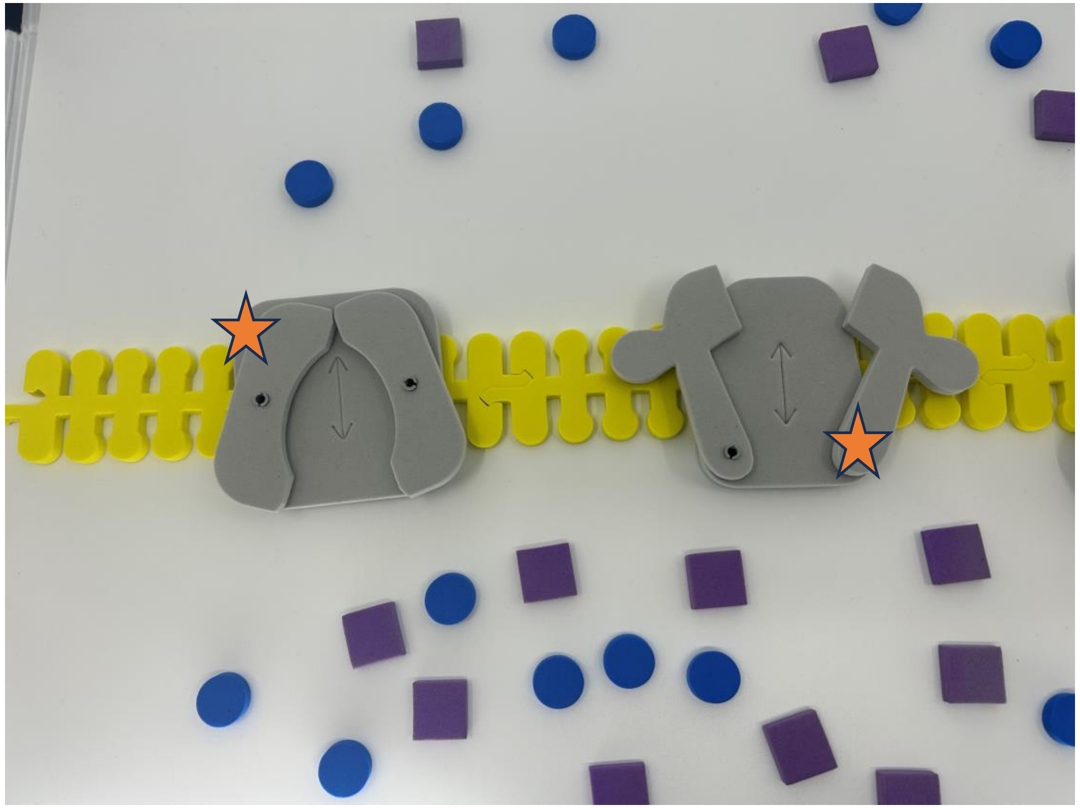
4 **Falling phase of the action potential** – K+ gates open, allowing K+ ions to move to the extracellular space. Na+ channels inactivation gates close, preventing the influx of Na+ ions. As more K+ ions leave the cell, the interior membrane becomes more negatively charged.

5 **Undershoot** - Activation and inactivation gates on Na+ channels are closed, but the gate on some K+ channels are still open. As the last K+ gates close, inactivation gates of Na+ channels open and the membrane is back at resting state.

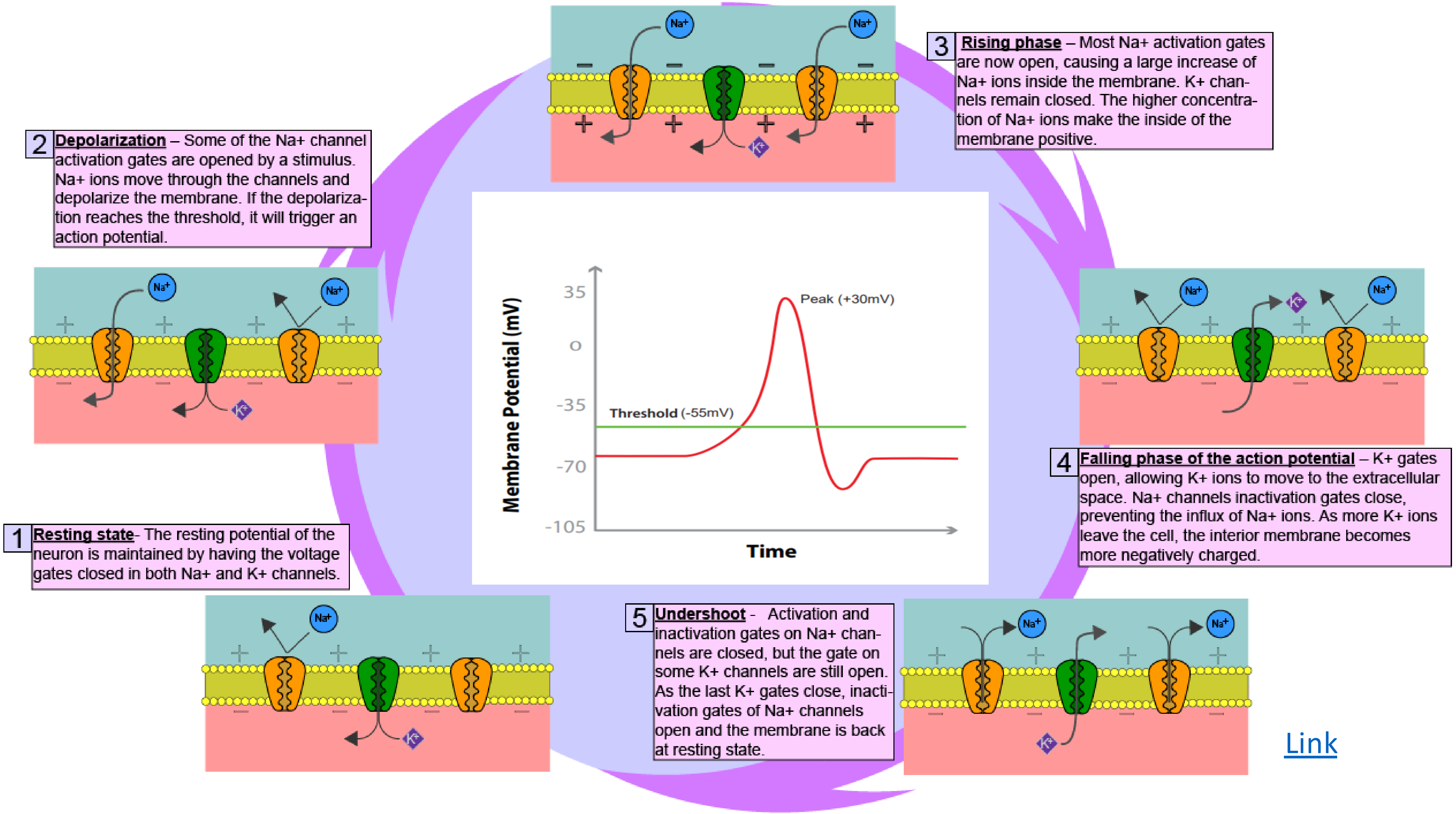
Link

What happened to the charge inside the membrane?



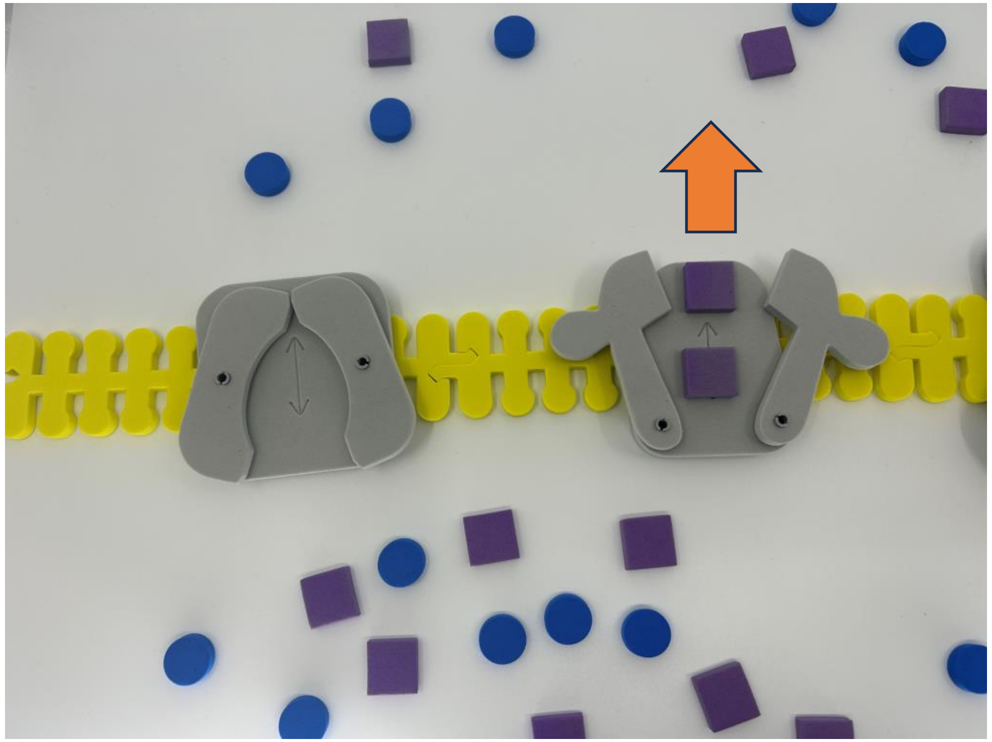


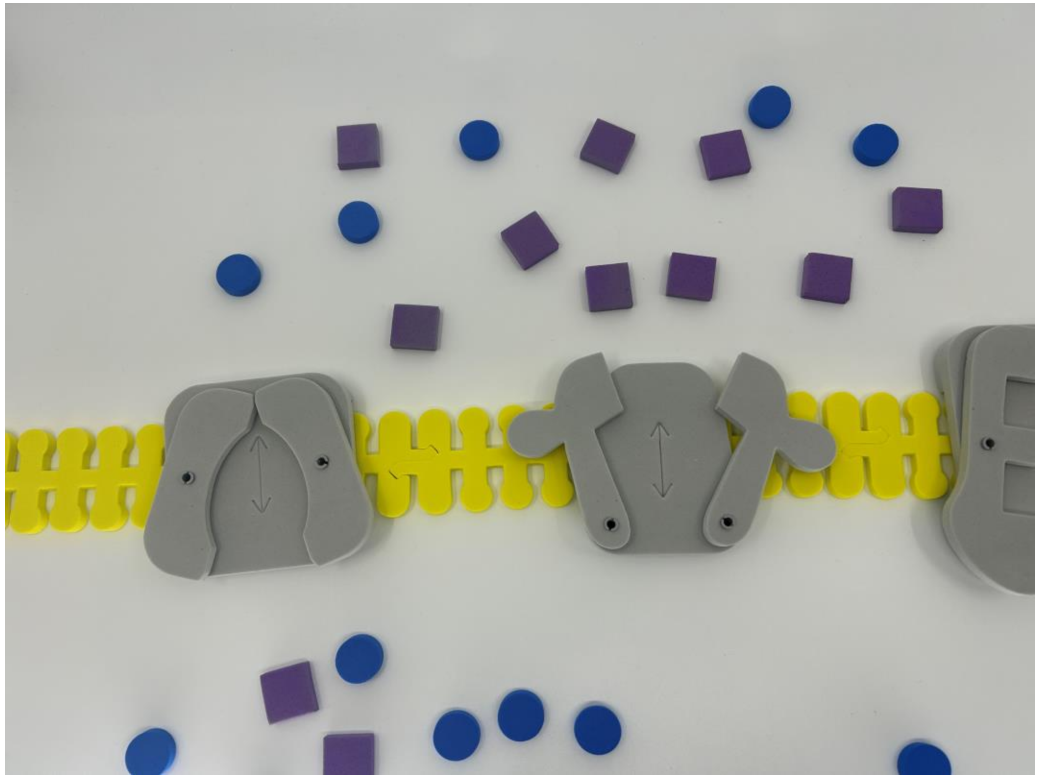
Life is complicated…



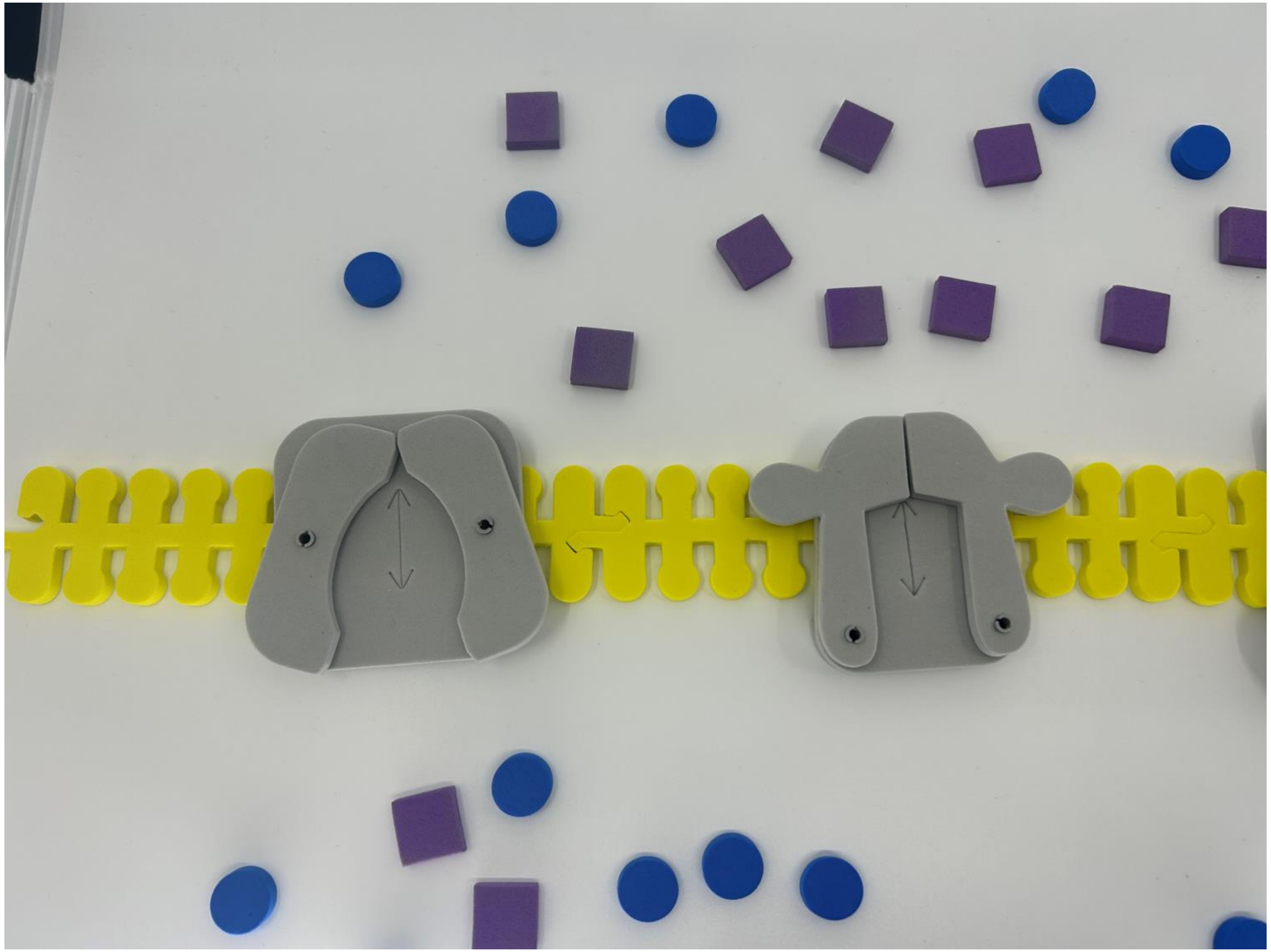
Link

Potassium (K+) moves next





Each channel is “tuned”

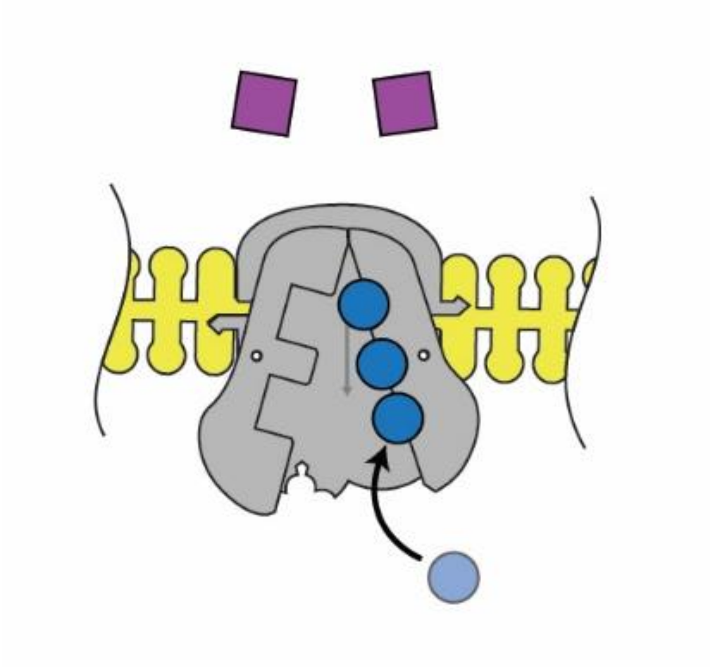


What type of cellular transport have we been investigating?

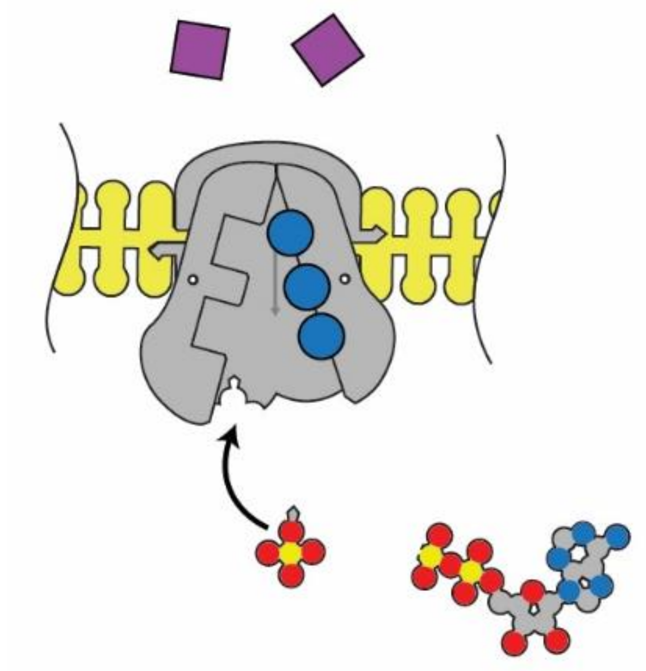
Where could you use this in your class?

How do we get back to a resting potential?

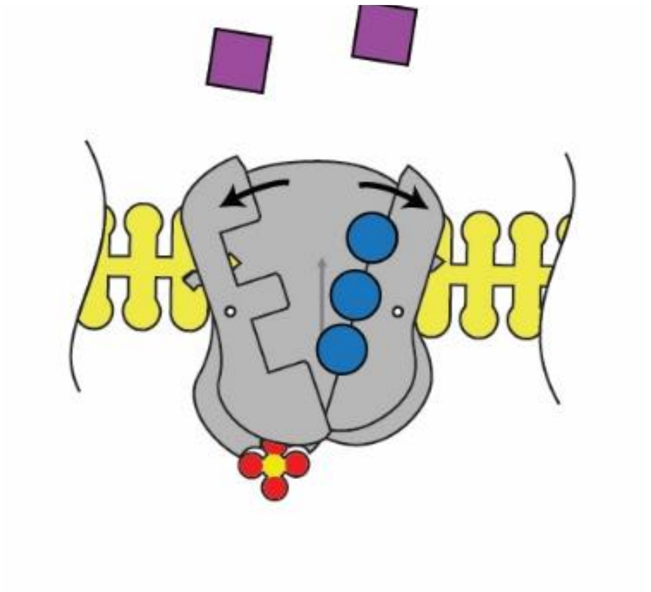
1. Sodium binds on the intracellular side.



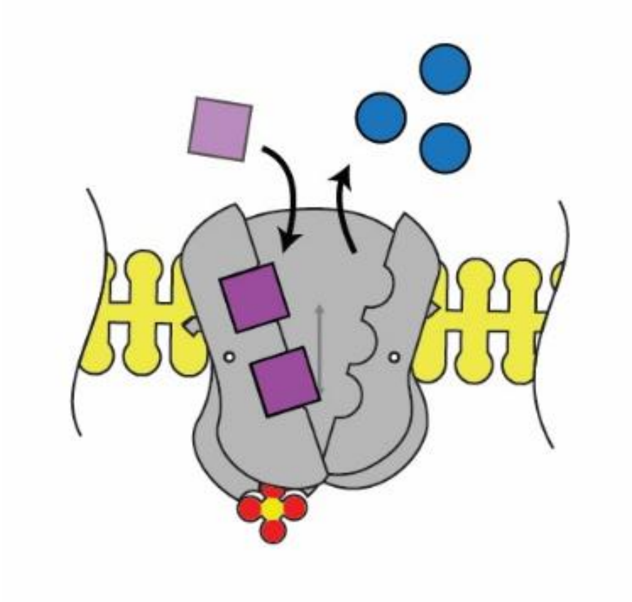
2. The pump is phosphorylated by ATP.



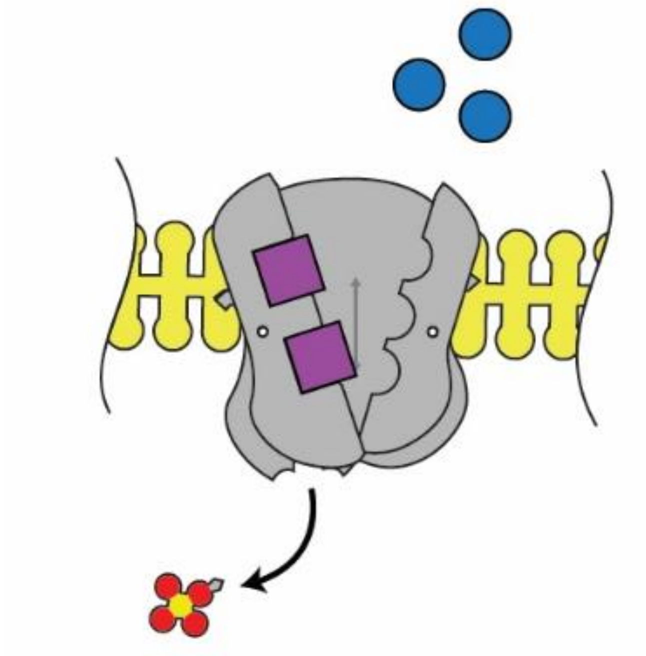
3. The pump shape changes, exposing the sodium to the extracellular space.



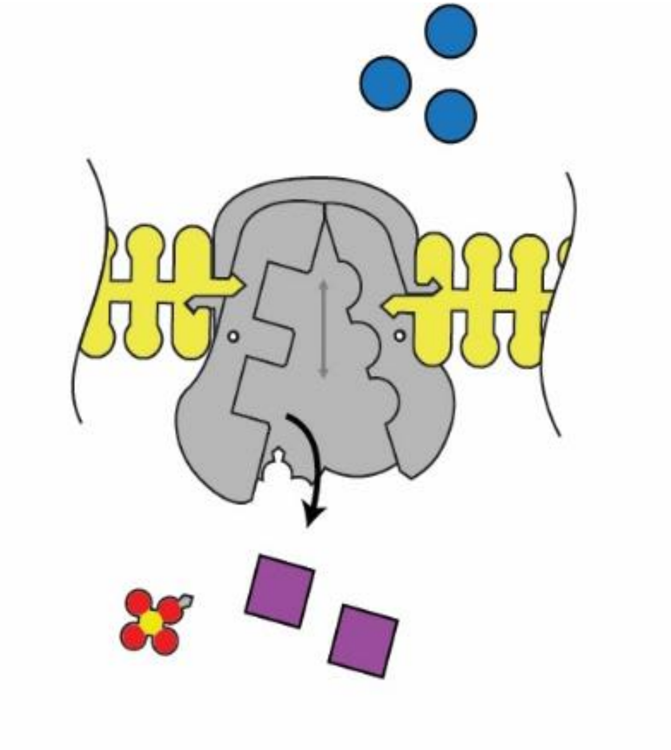
4. Binding affinity changes to release Na+ and take in K+.



5. Phosphate detaches.



6. Original shape is restored, releasing K+ into the cell.



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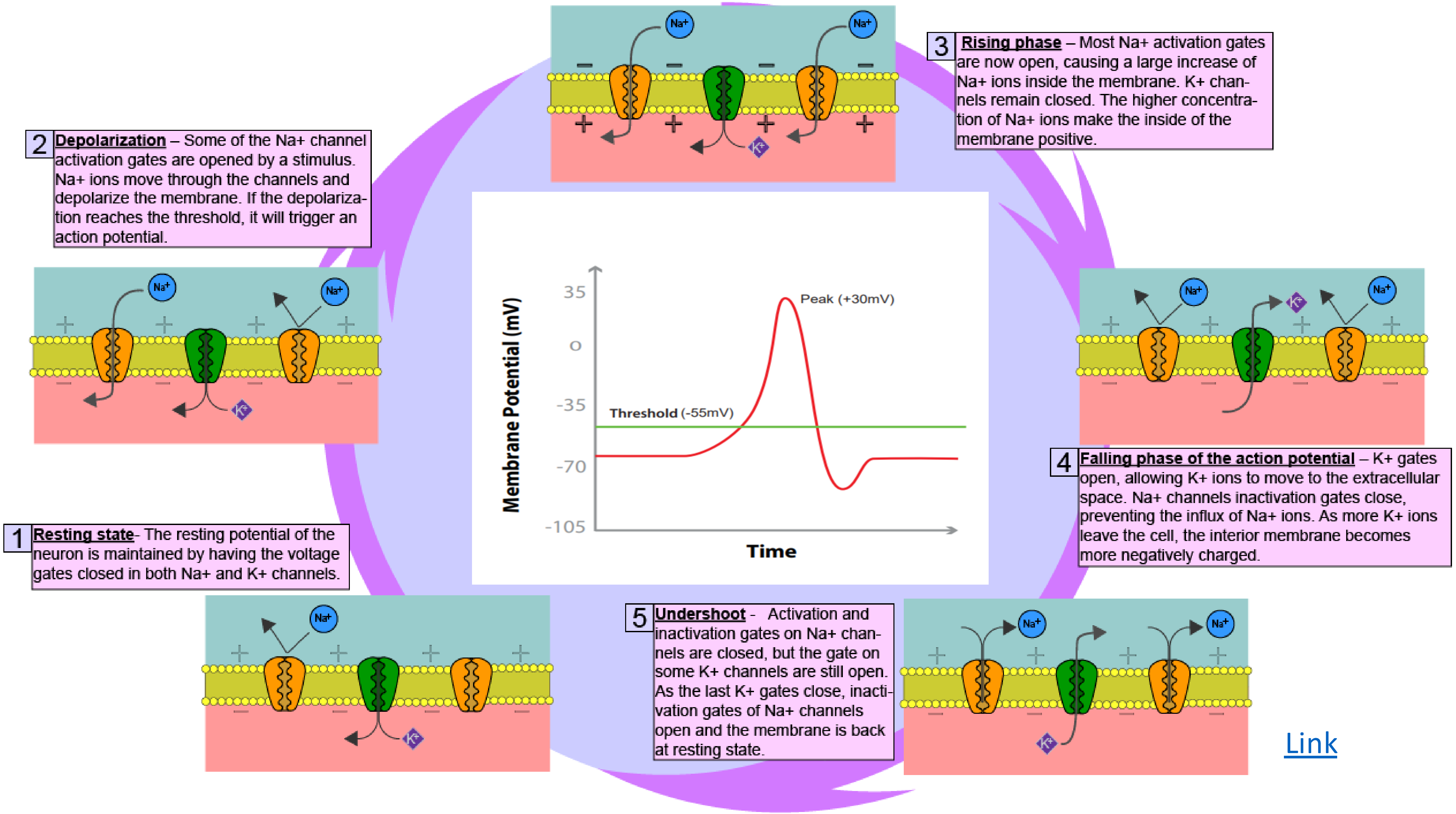

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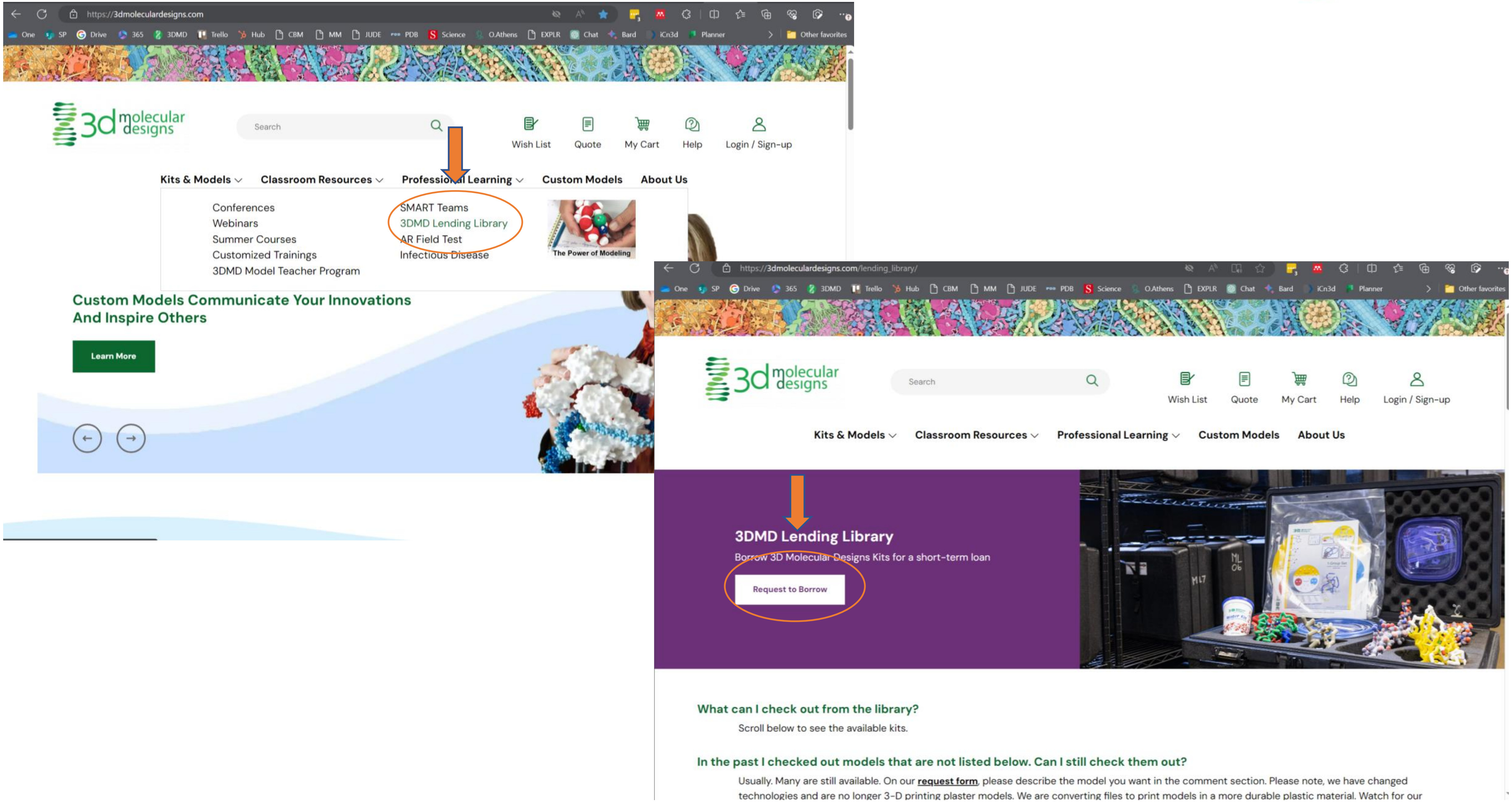
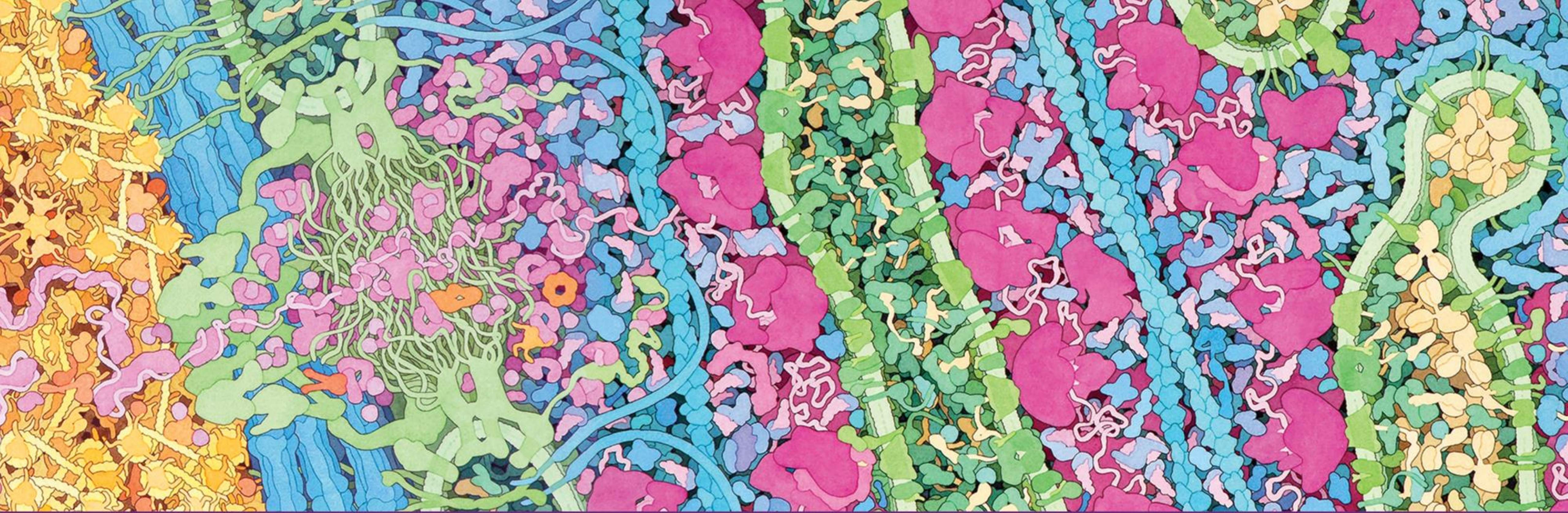
Lending Library



TEKS

- **Biology (9-12)**:

Biology (9-12):
(4) Science concepts. The student knows the structures and functions of biomolecules. The student is expected to:
- (B) explain the role of water in the function of biomolecules.
- (C) compare the structures and functions of different types of biomolecules, including carbohydrates, lipids, proteins, and nucleic acids.



3d molecular designs

Transforming Science Learning