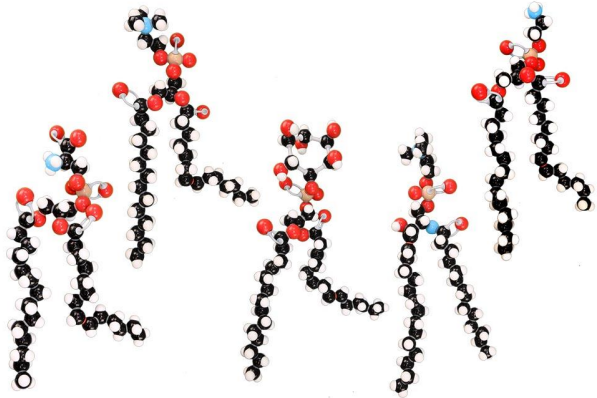
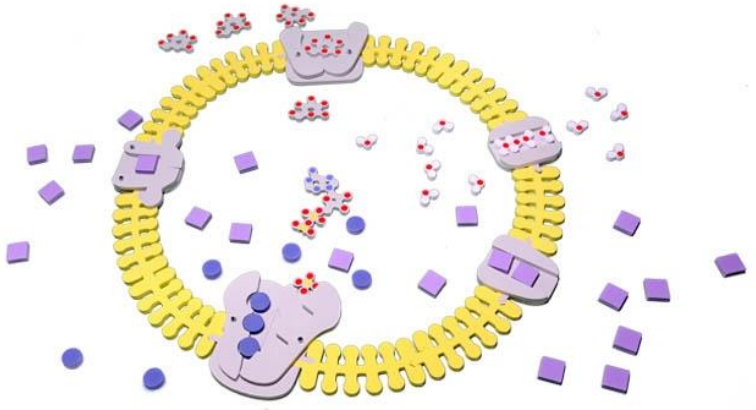
Get a Move On: Modeling Molecular Transport Across Cell Membranes





Presenter:

RUTH HUTSON, MSSE

3D Molecular Designs Science Educator

Workshop Learning Goals

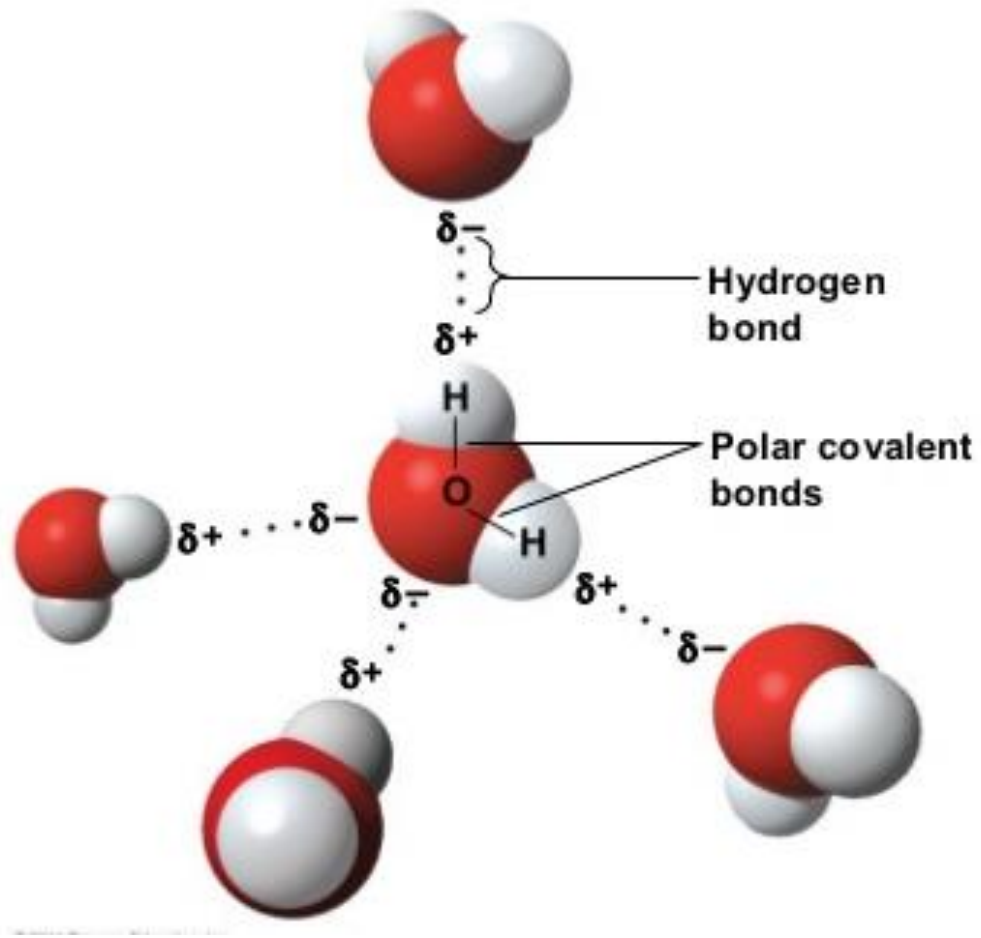
- Model the polar nature of water
- Determine how similarities and differences in phospholipid structure affect membrane permeability.
- Construct and cross cell membrane.
- Compare and contrast multiple models to better understand cellular processes and apply that knowledge to a case study.
- Have fun**!**

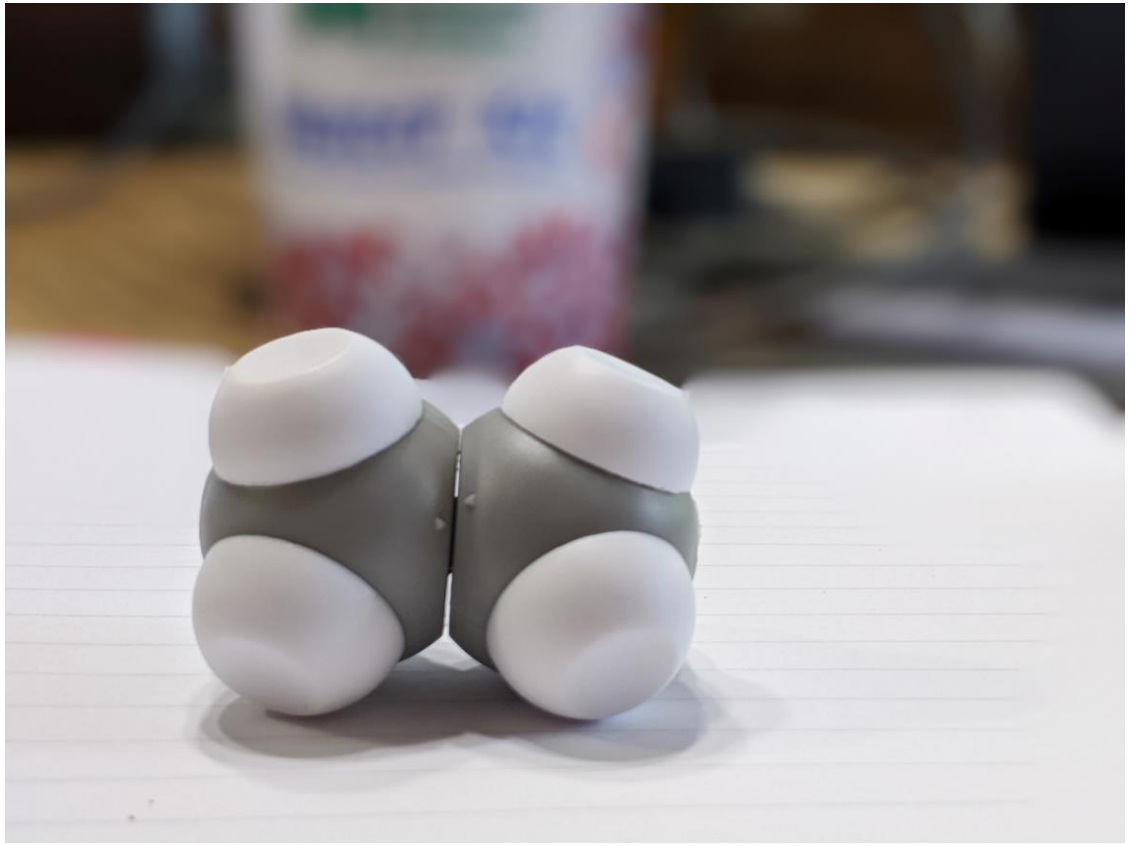
Seventeen-year old female was at a public archeology dig doing field work in June when she suddenly became ill. She complained of nausea and vomited once. She had a headache and her legs were cramping. She left the field site early and went home where she rested, drank water, and stayed inside where it was air conditioned.

What is your initial diagnosis?

What would you encourage the young lady to do?

- 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?


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



What patterns do you see?

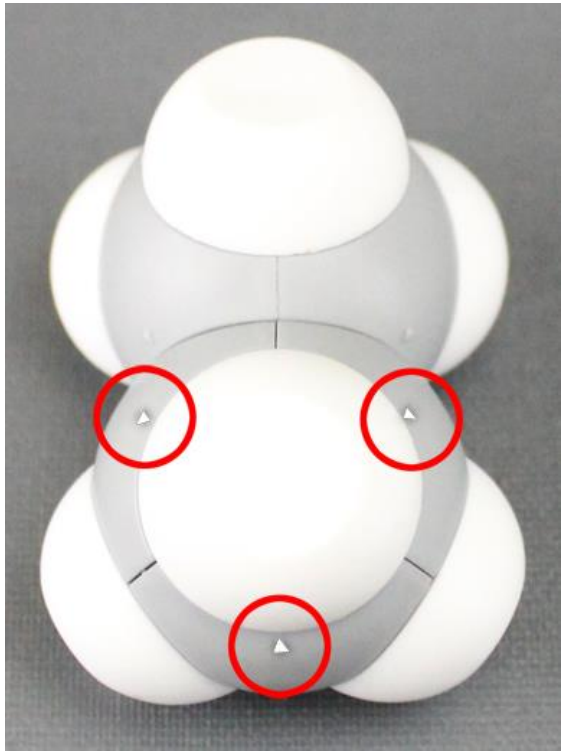
What questions do you have?

How does this molecule interact with water molecules ?

What patterns do you see?

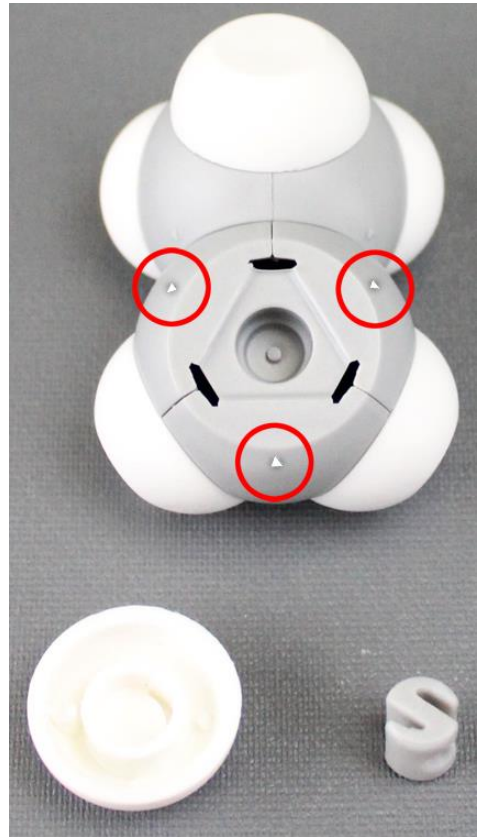
What questions do you have?

A closer look at solubility



Molecular Manipulation

A closer look at solubility

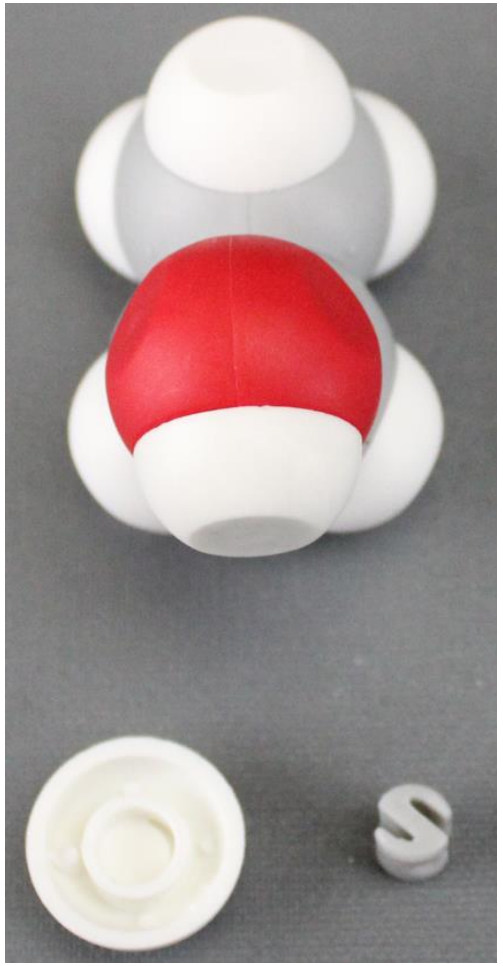


How does this molecule interact with water molecules ?

What patterns do you see?

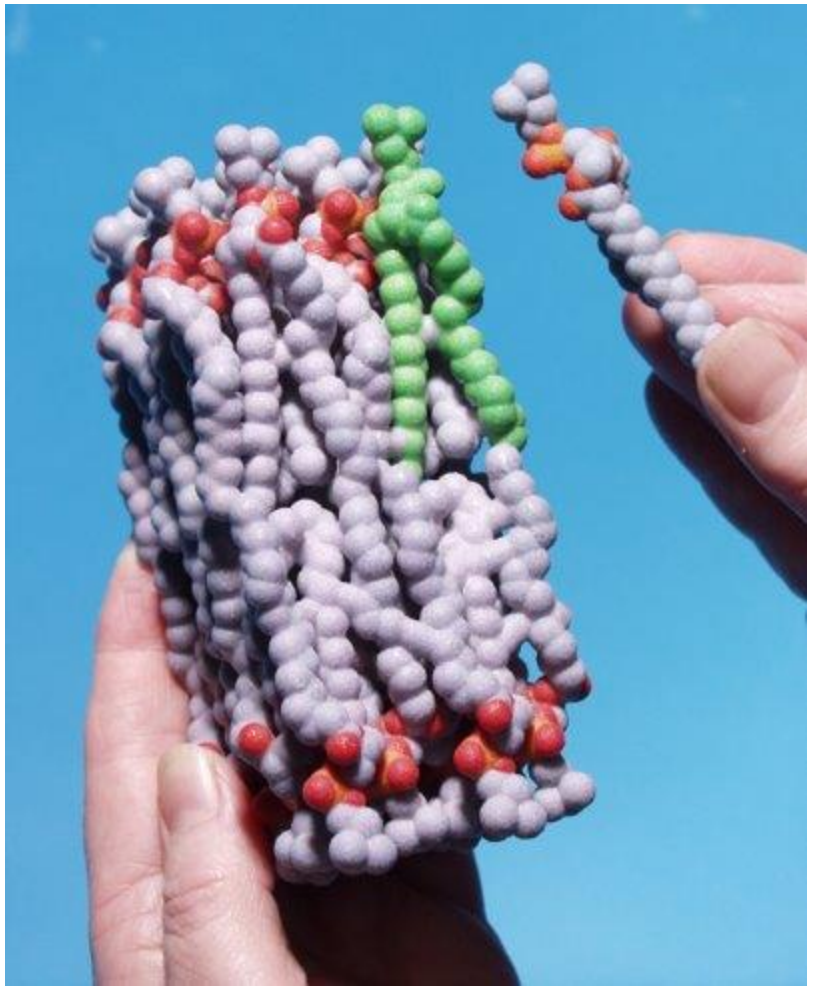
What questions do you have?

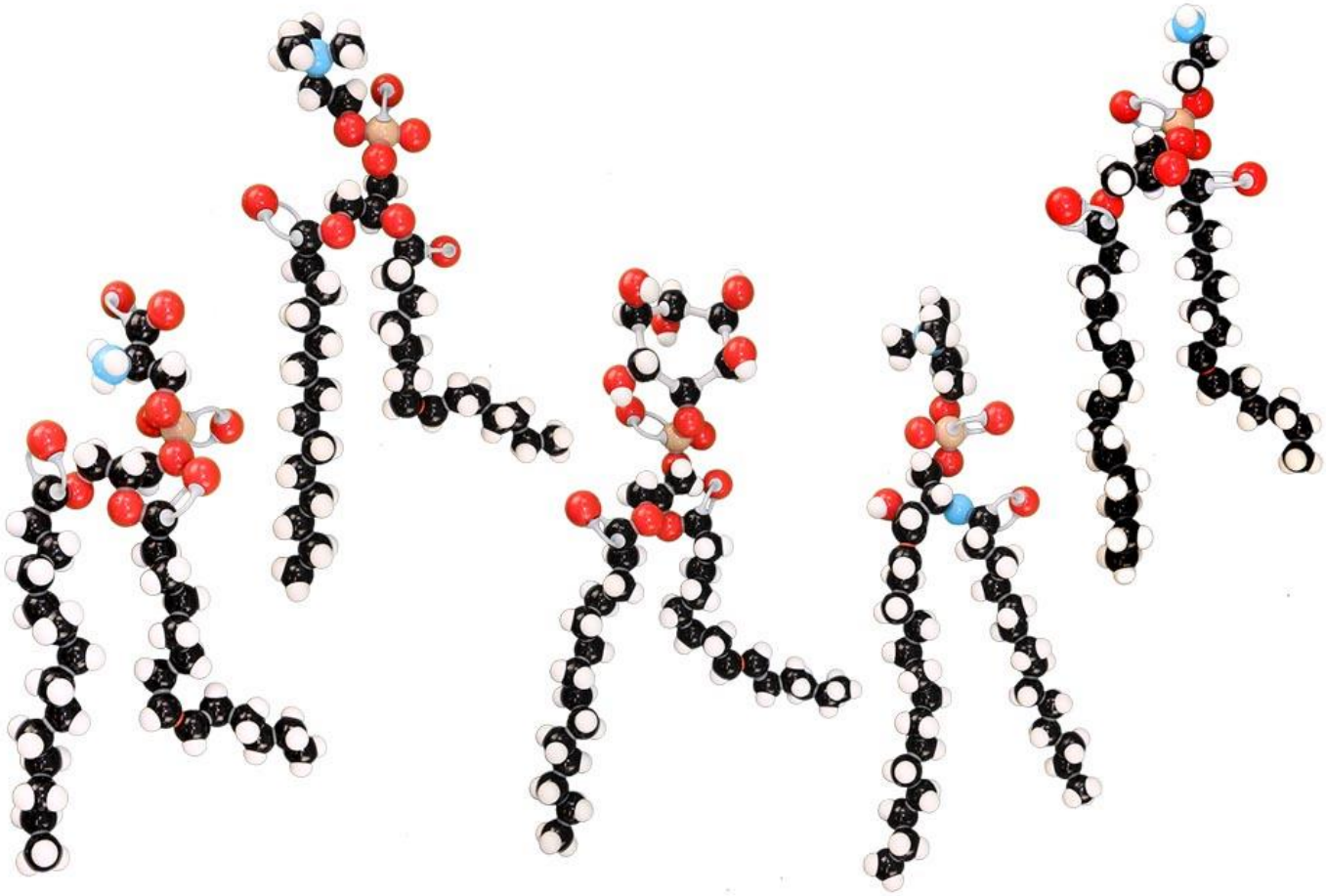
A closer look at solubility



Getting through the cell membrane

How does a polar molecule like water diffuse through a largely hydrophobic bilayer?





Getting Through the Cell Membrane

Examine the phospholipid molymod at your table.

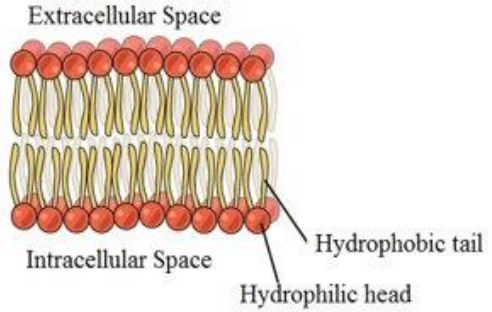
- Describe the overall structure of your model
- What atoms are present? What colors represent these atoms?
- What are two questions you have about your model?

Getting Through the Cell Membrane

Compare and contrast your group's phospholipid to another group's phospholipid.

Speculate why a cell membrane would have different phospholipids.

Focus on Phospholipid Heads



Phosphatidylcholine

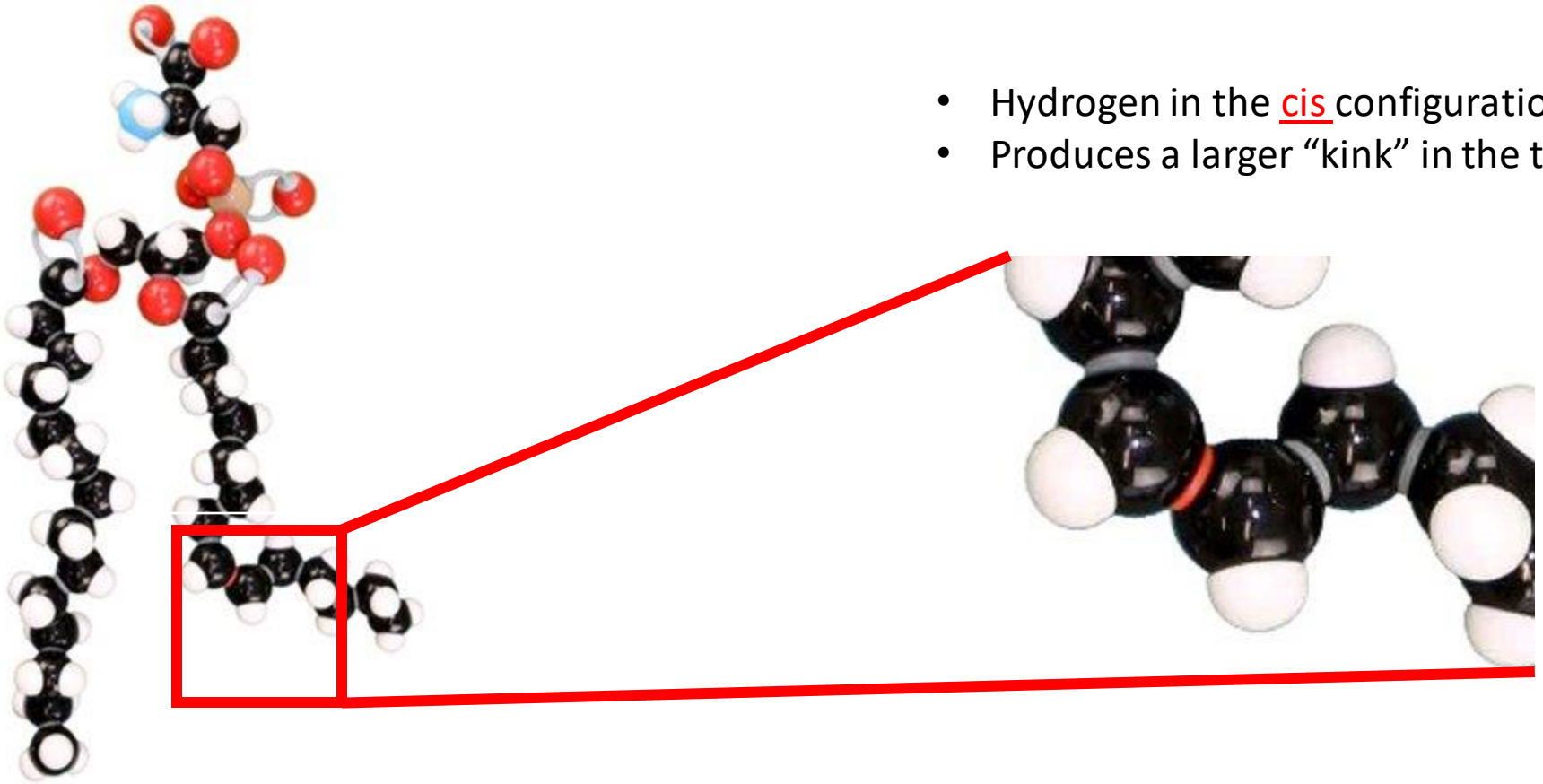
Sphingomyelin

Phosphatidylethanolamine

Phosphati**dylserin**e

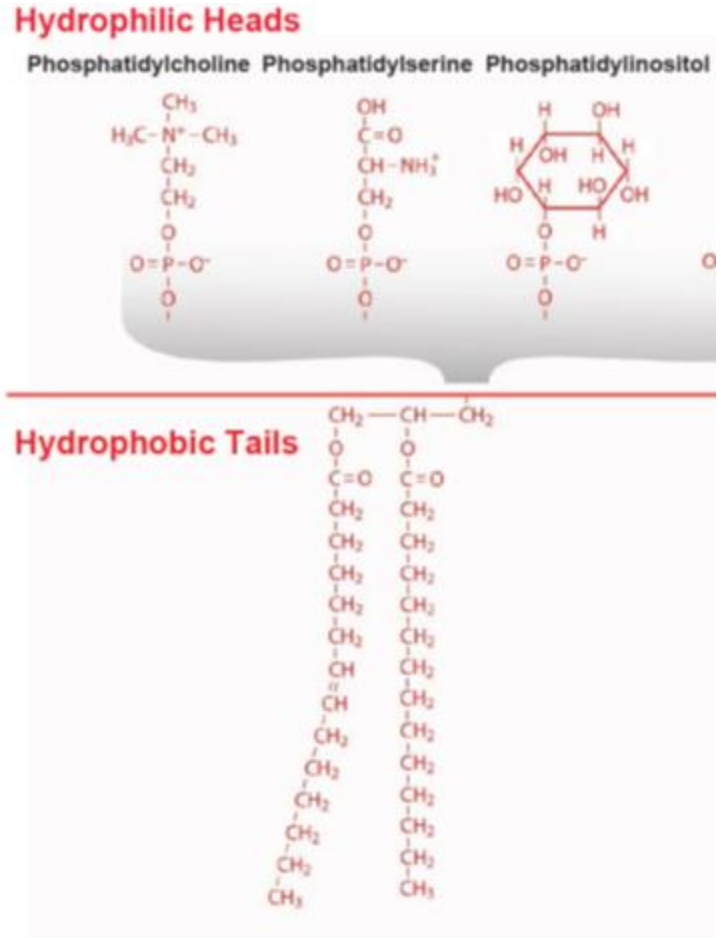
Phosphatidylinositol

Focus on Phospholipid Tails



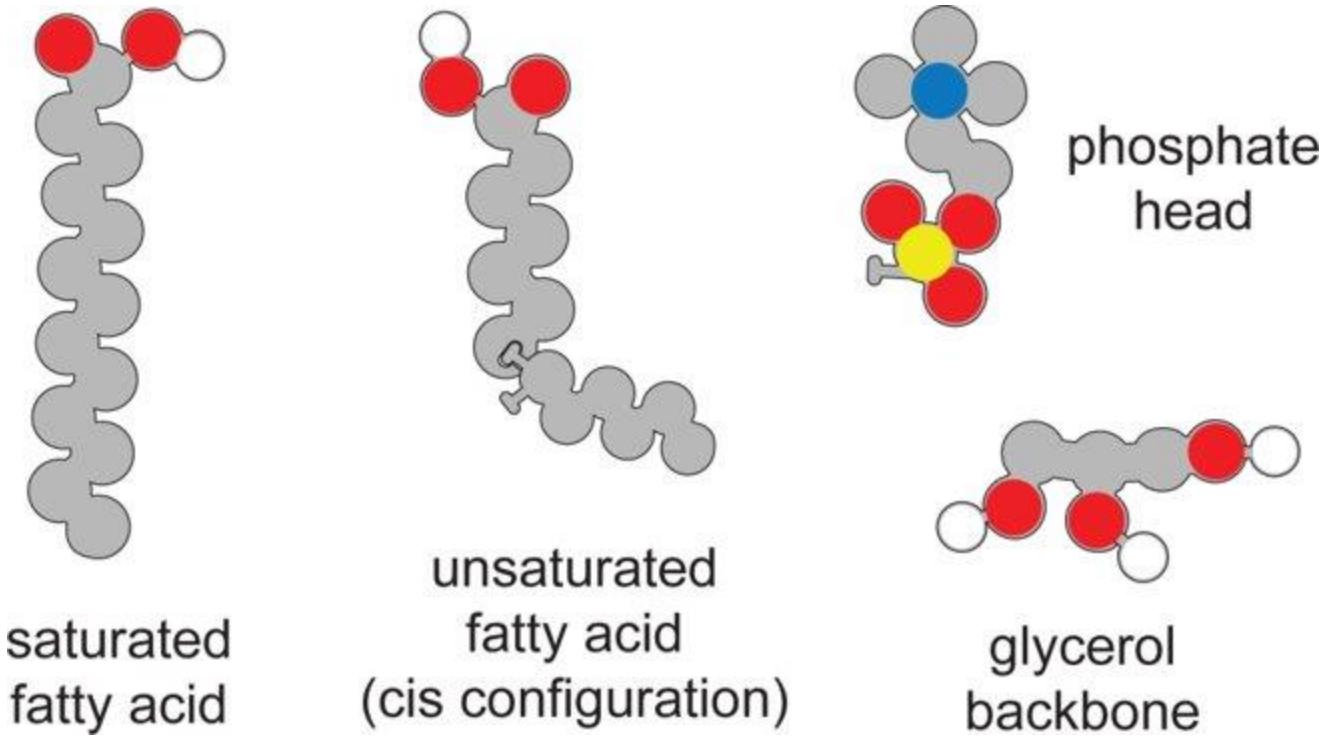
- Hydrogen in the cis configuration
- Produces a larger “kink” in the tail

Modeling the Membrane: Phospholipids

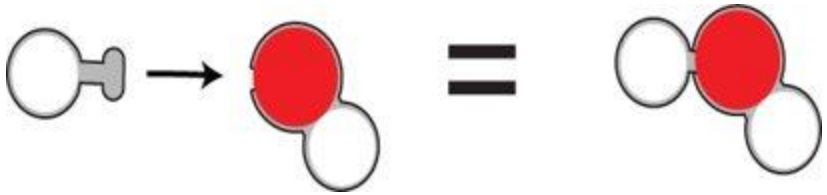


Using multiple models help explain nuance in the phenomena we are typing to explain.

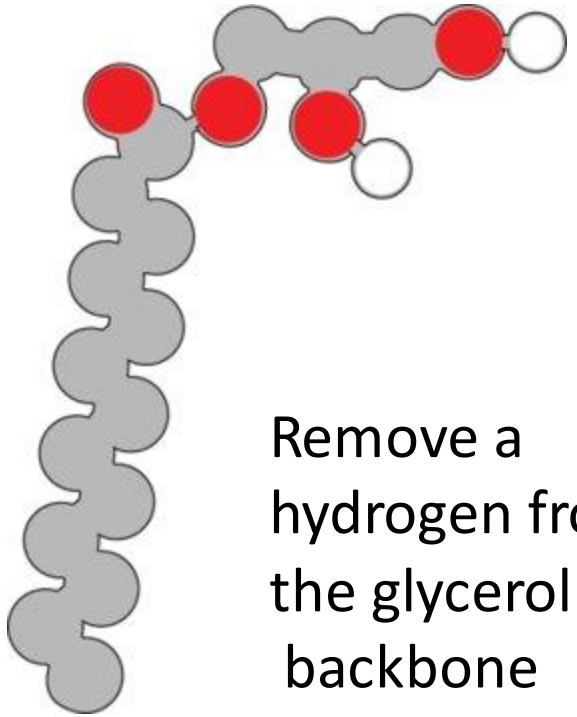
Constructing A Phospholipid



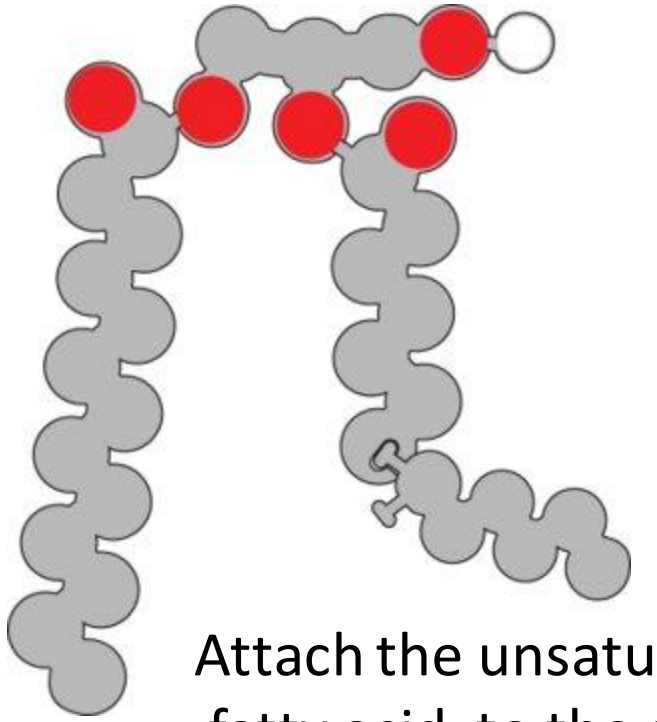
Constructing A Phospholipid



Join the hydrogen and the hydroxyl group to make water.



Remove a hydrogen from the glycerol backbone

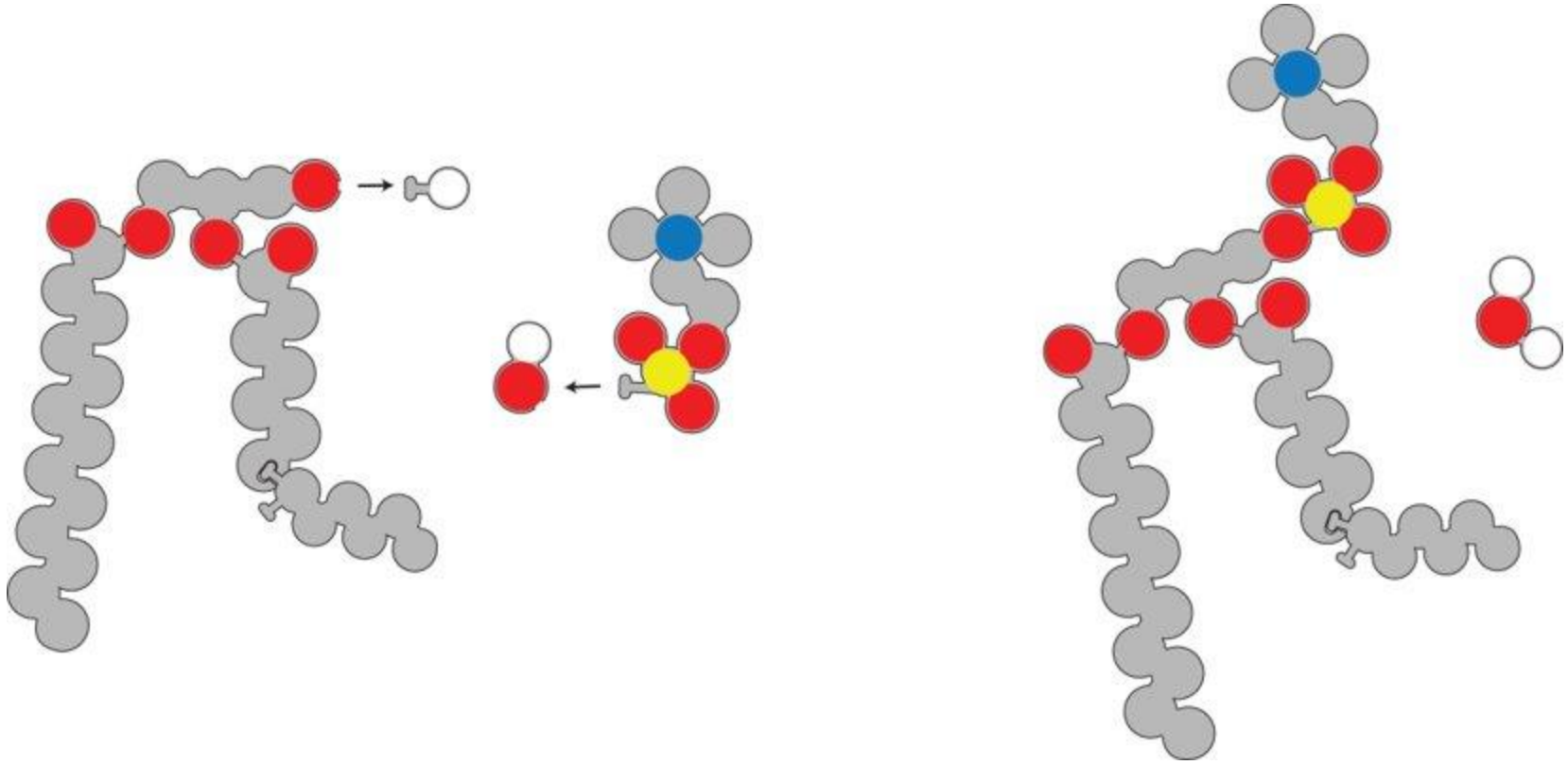


Attach the unsaturated fatty acid to the glycerol backbone

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.

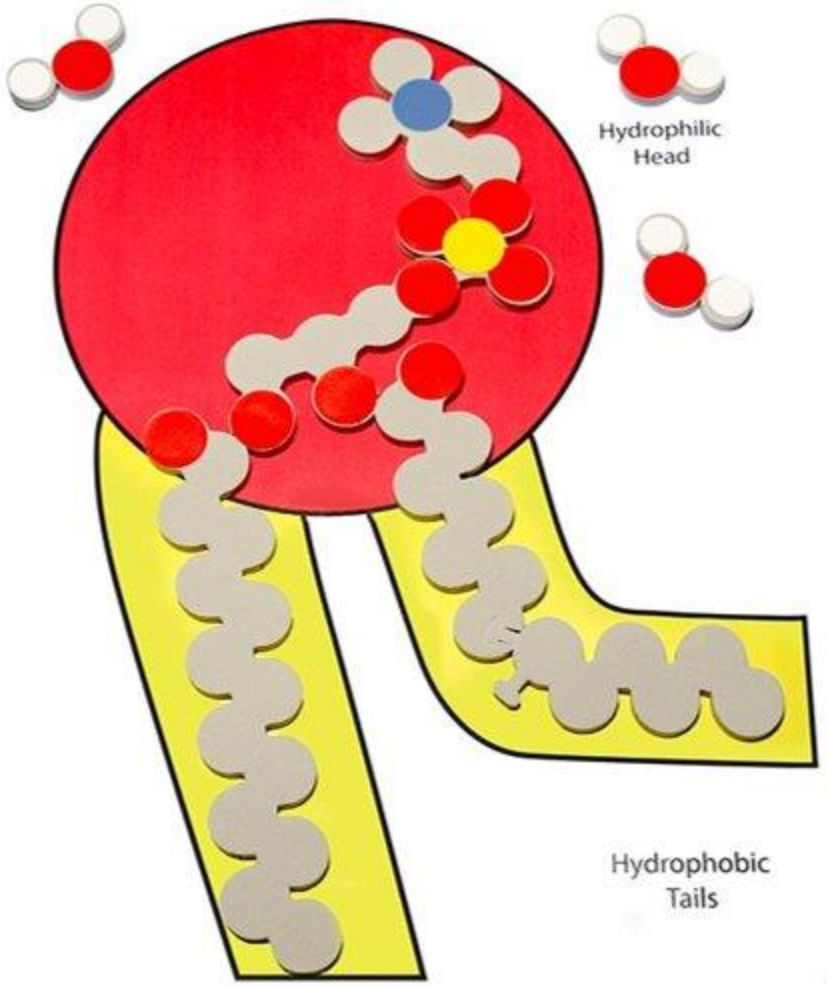


Constructing A Phospholipid

What do all three models have in common?

How are the models different?

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

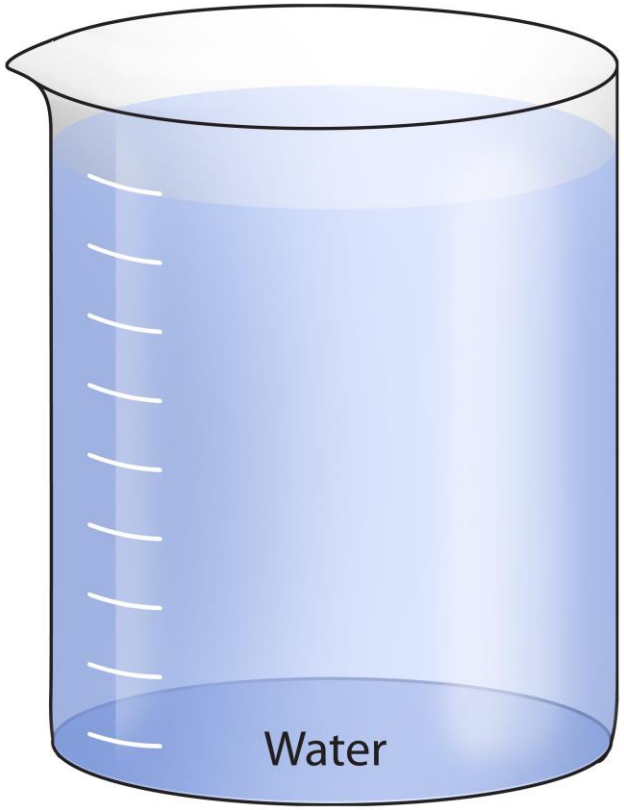


Building a Cell Membrane

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.



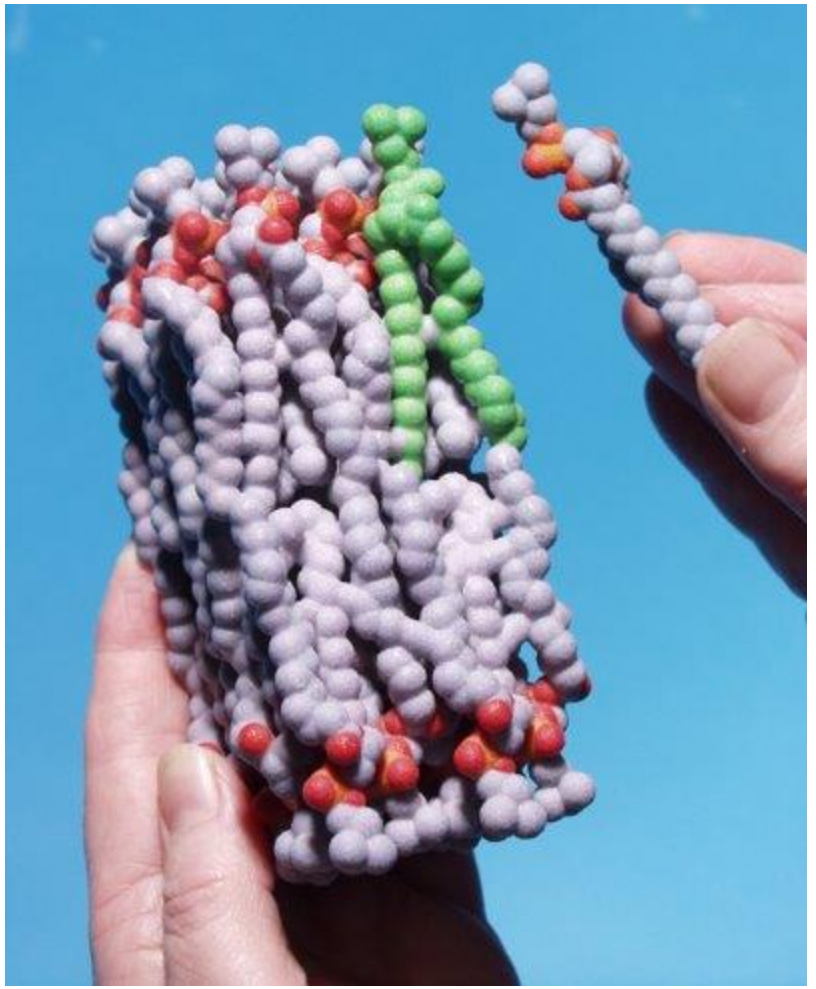
The next day the young lady awoke with swollen ankles, a more severe headache, extreme fatigue, and throughout the day she continued to vomit.

Later in the afternoon, she visited her General Practitioner who ordered a urine sample and blood test. She also had a negative strep test.

How your initial diagnosis changed based on the new information?
What other information do you need to know?

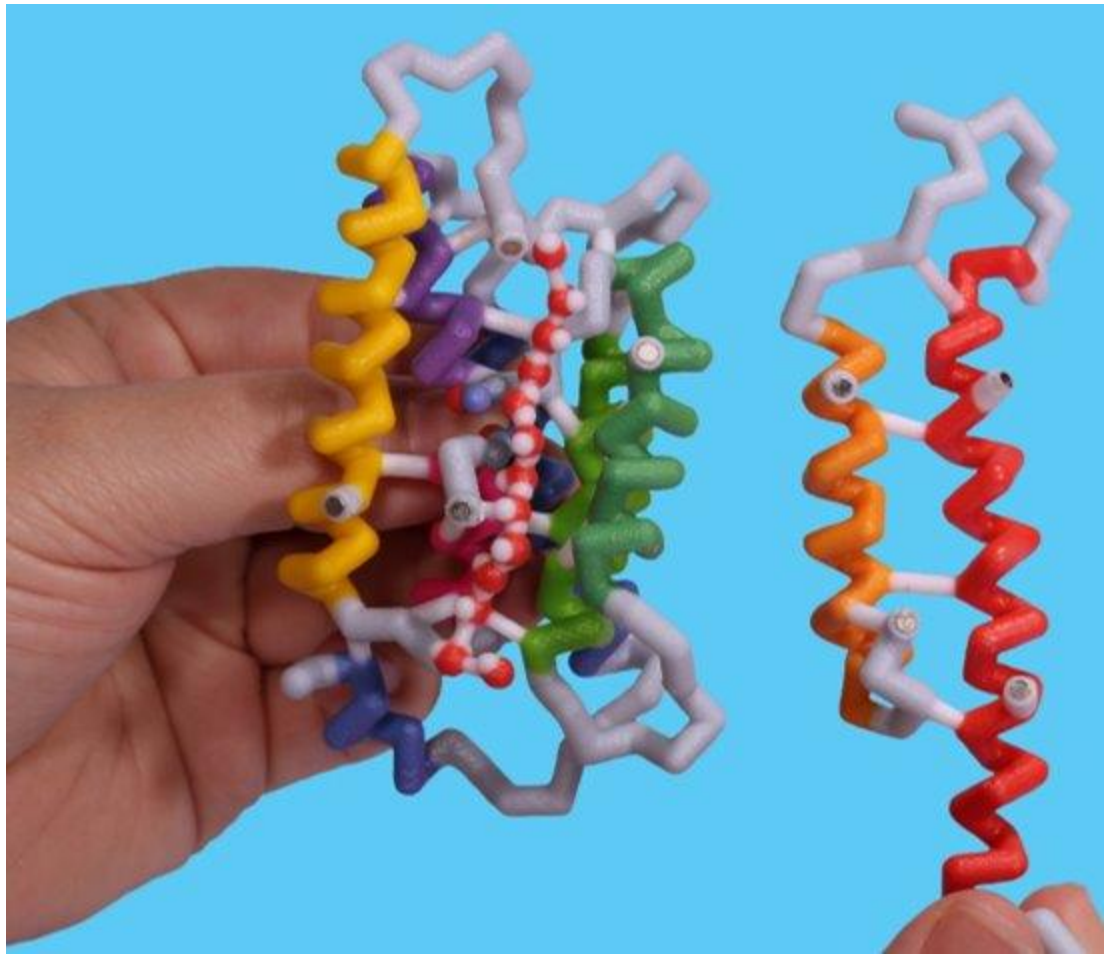
Getting through the cell membrane

How does a polar molecule like water diffuse through a largely hydrophobic bilayer?



Enter AQUAPORIN!

- Transport protein that spans the membrane
- Retrieve the aquaporin channel protein from the phospholipid and membrane kit and let's compare it to this 3-D printed model.



Results of Lab work
Basic Metabolic Panel, Simplified

Na: 120	Cl: 95	BUN: 9	Glucose: 60
K: 3.0	CO2: 25	Cr: 0.8	

Results of Lab work Basic Metabolic Panel, Simplified

Na: 120	Cl: 95	BUN: 9	Glucose: 60
K: 3.0	CO_2: 25	Cr: 0.8	

Na: 135-145	Cl:95-105	BUN: 7-24	Glucose: 60-120
K: 3.5-5.1	CO_2:22-28	Cr: 0.7-1.4	

Using the Phospholipid and Membrane Transport Kit, how would you model this phenomenon?

Results of Lab work

Urinalysis

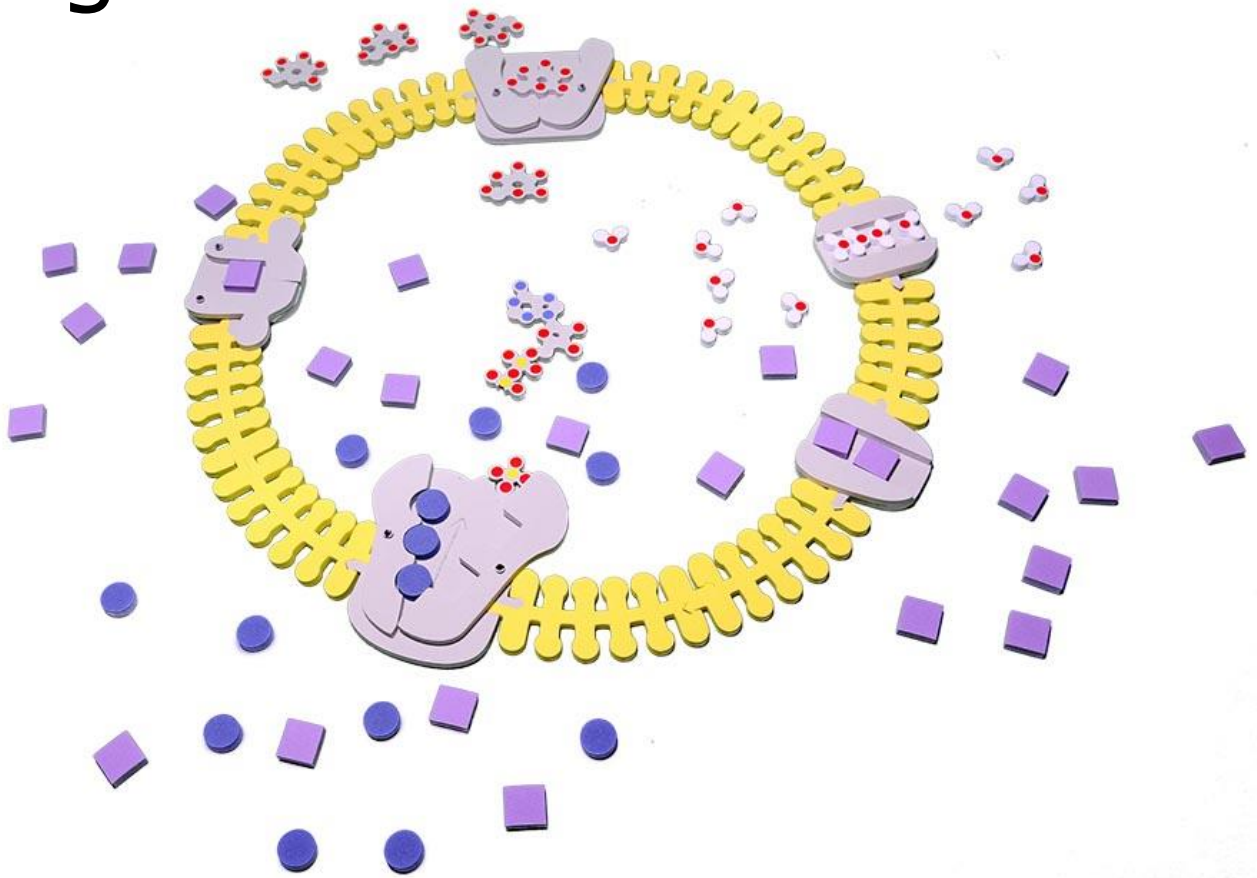
Appearance: Clear
pH: 7.0
Specific Gravity: 1.00
Protein: 0
Glucose: 75 mg/d
Ketones: 0

Results of Lab work
Urinalysis

Appearance: Clear (Clear to Yellow)
pH: 7.0 (4.5-7.2; optimum: 6.0)
Specific Gravity: 1.00 (1.005-1.025)
Protein: 0
Glucose: 75 mg/d
Ketones: 0

Using the Phospholipid and Membrane Transport Kit, how would you model this phenomenon?

Let’s investigate some membrane channels

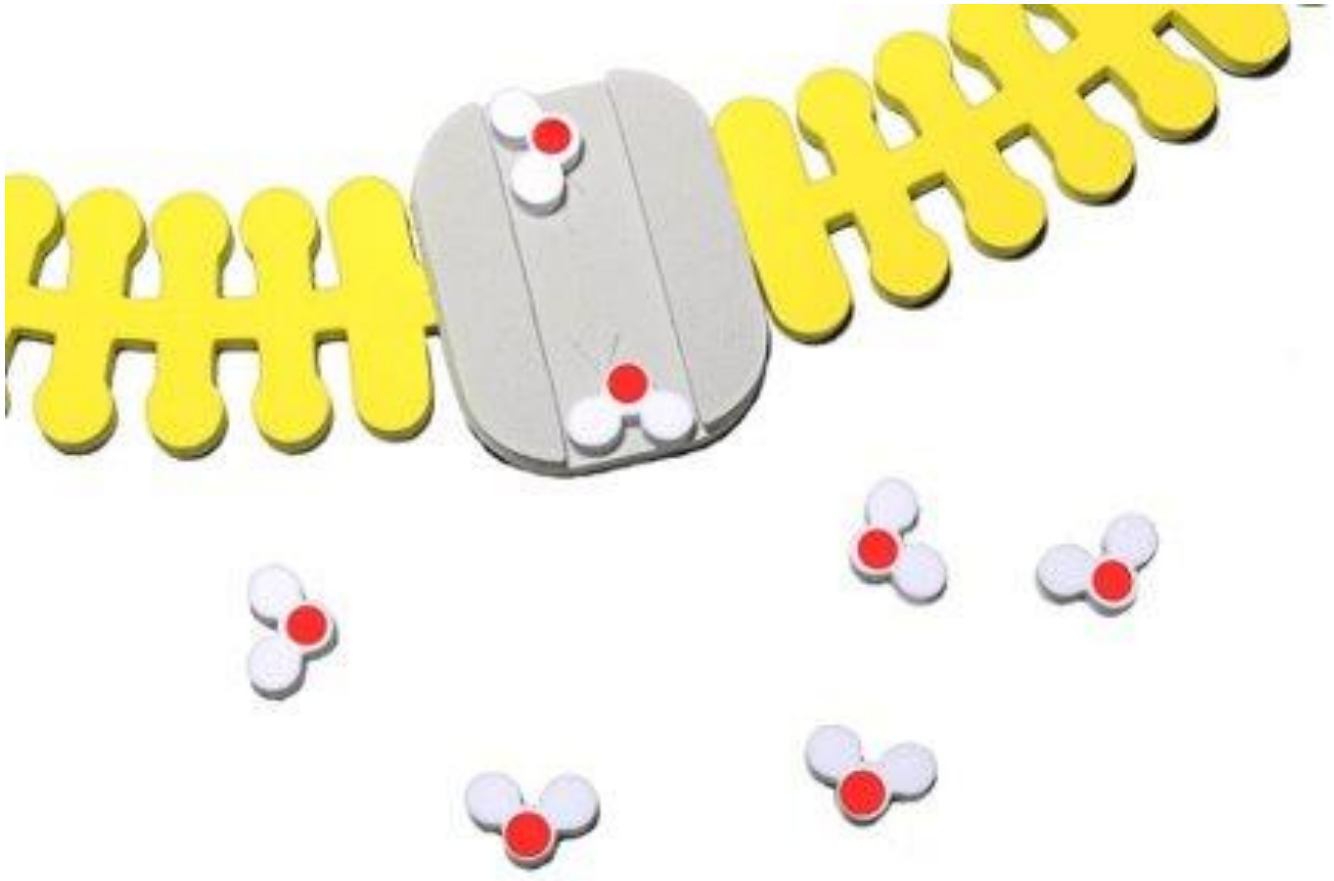


Passive Transport:

Aquaporin

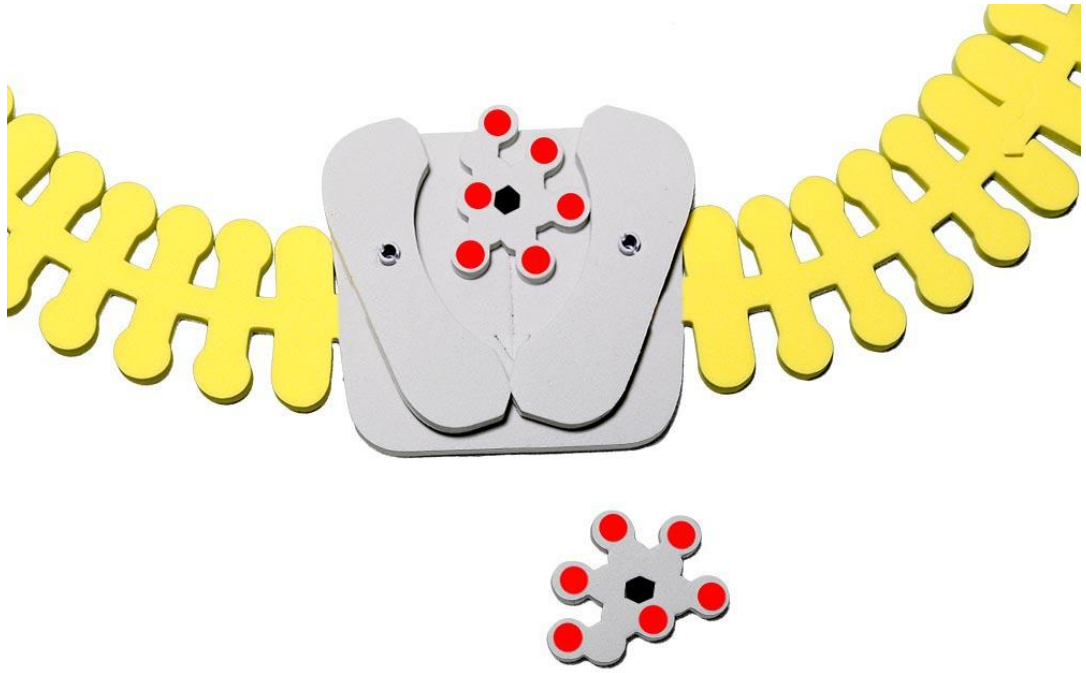
K+ Leak Channel

Gated K+ Channel

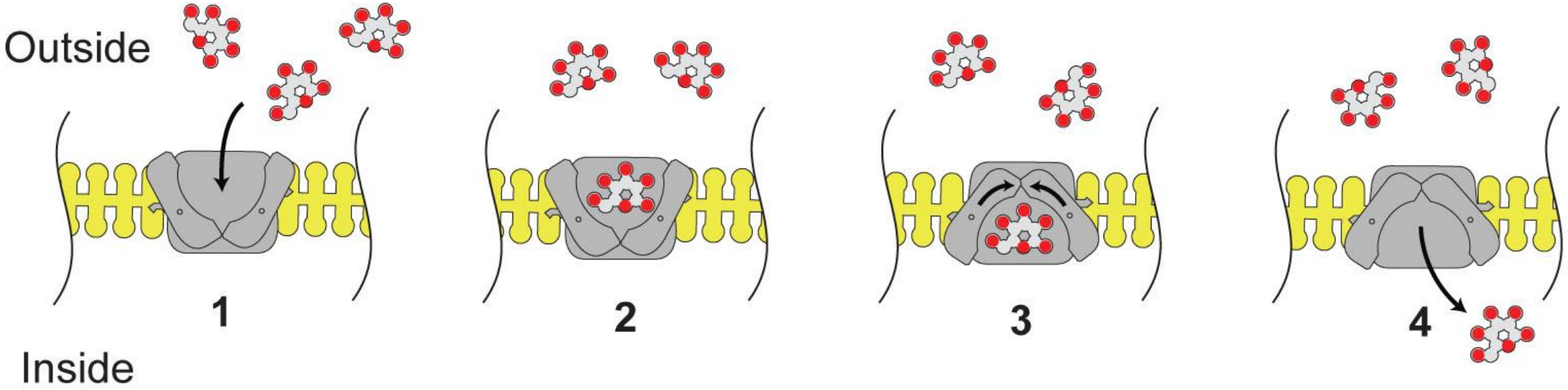


Passive Transport with Carrier Protein:

Glucose Transporter 1 (Glut 1)



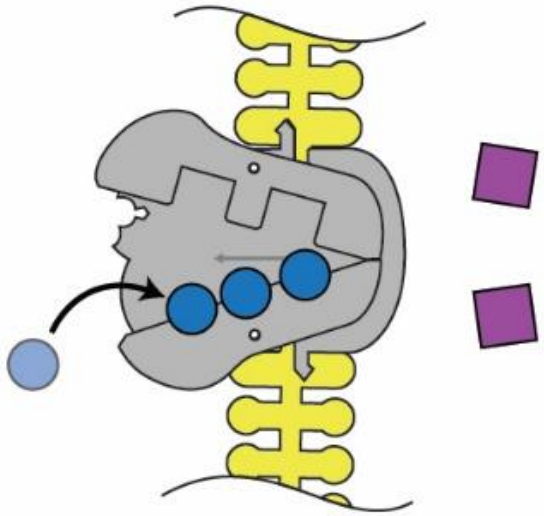
Modeling passive transport with a carrier protein



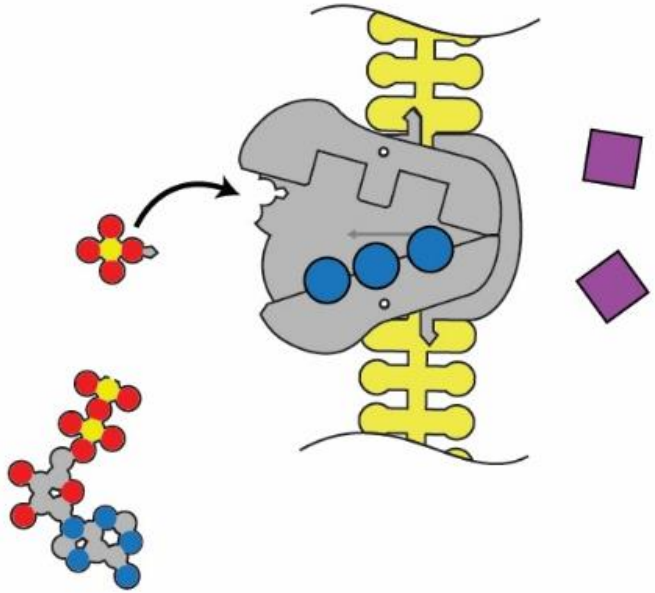
Active Transport

Sodium-Potassium Pump

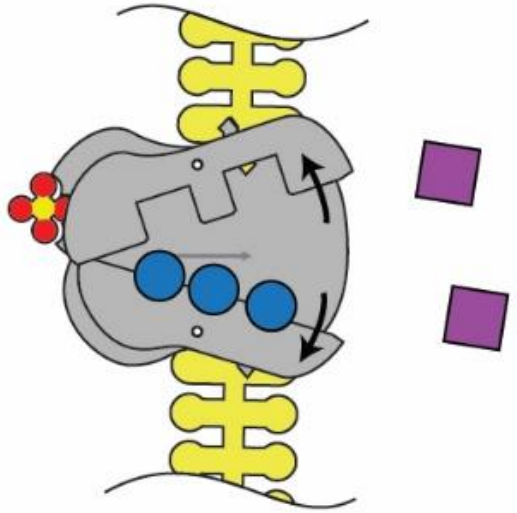
1. Sodium binds on intracellular side.



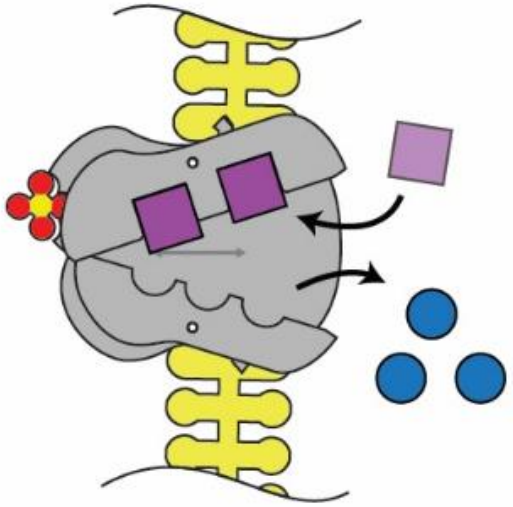
2. The pump is phosphorylated by ATP.



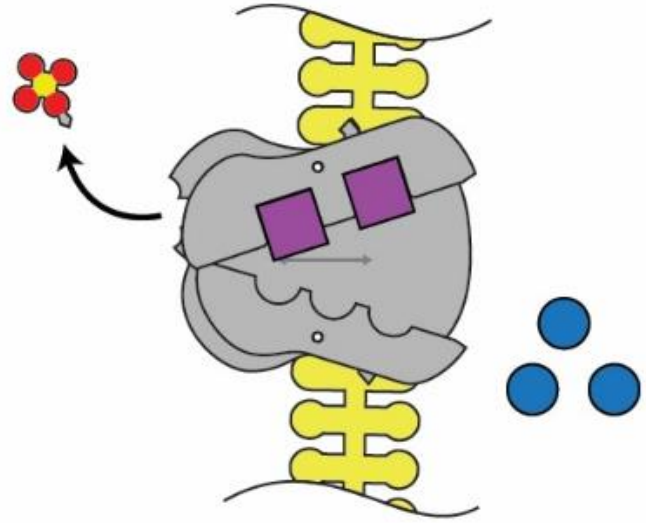
3. The pump shape changes, exposing the sodium to the extracellular space.



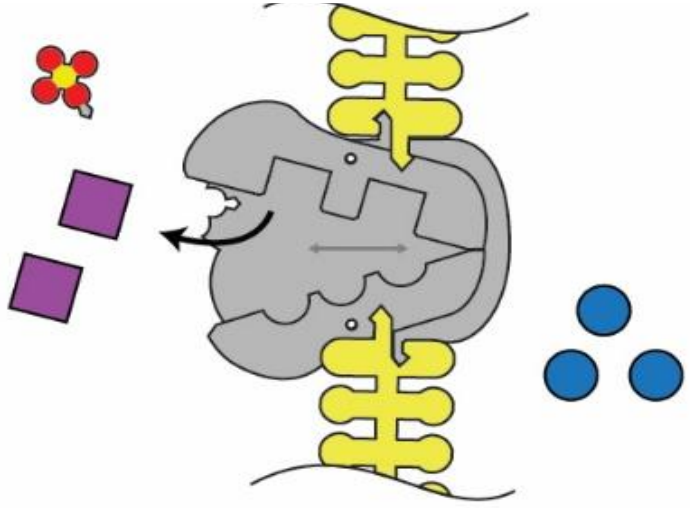
4. Binding affinity changes to release Na+, and take in K+.

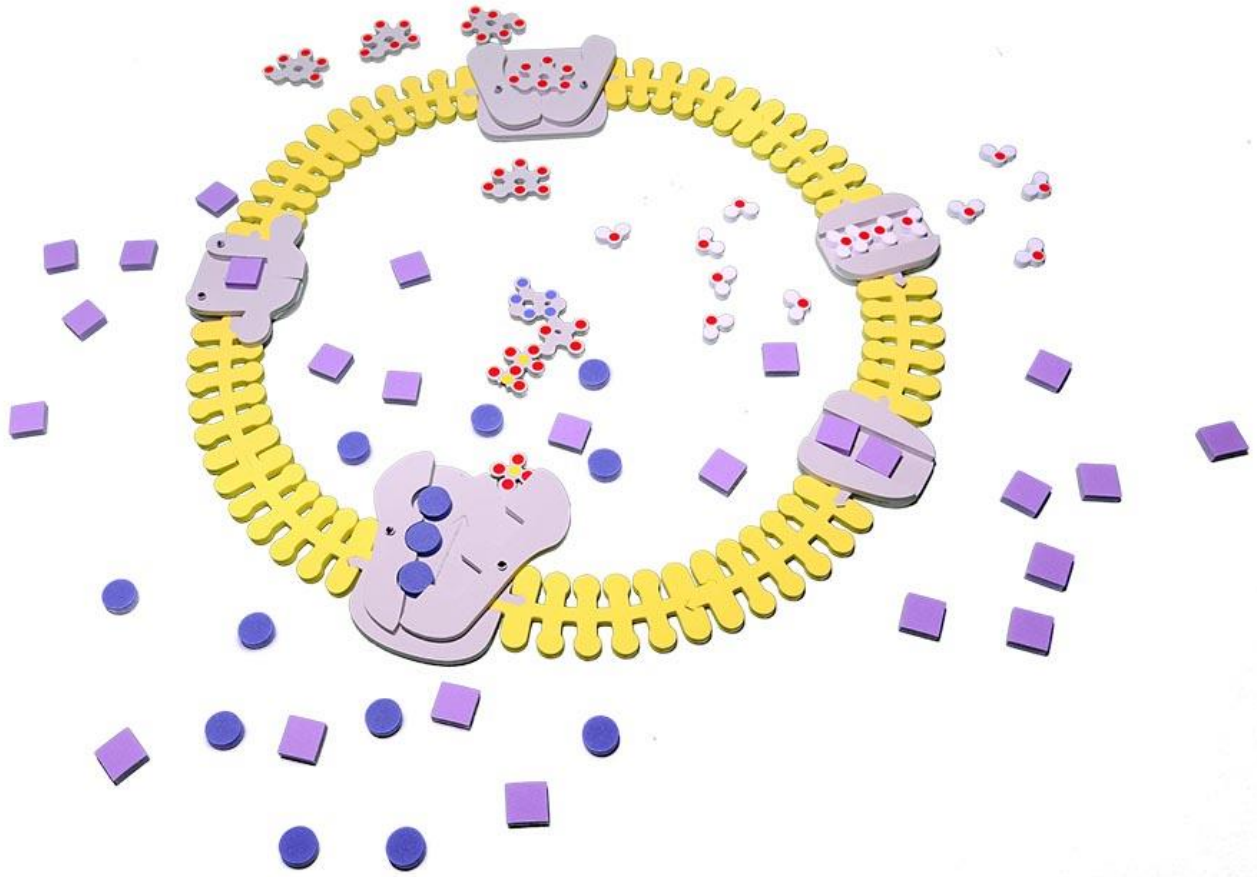


5. Phosphate detaches.

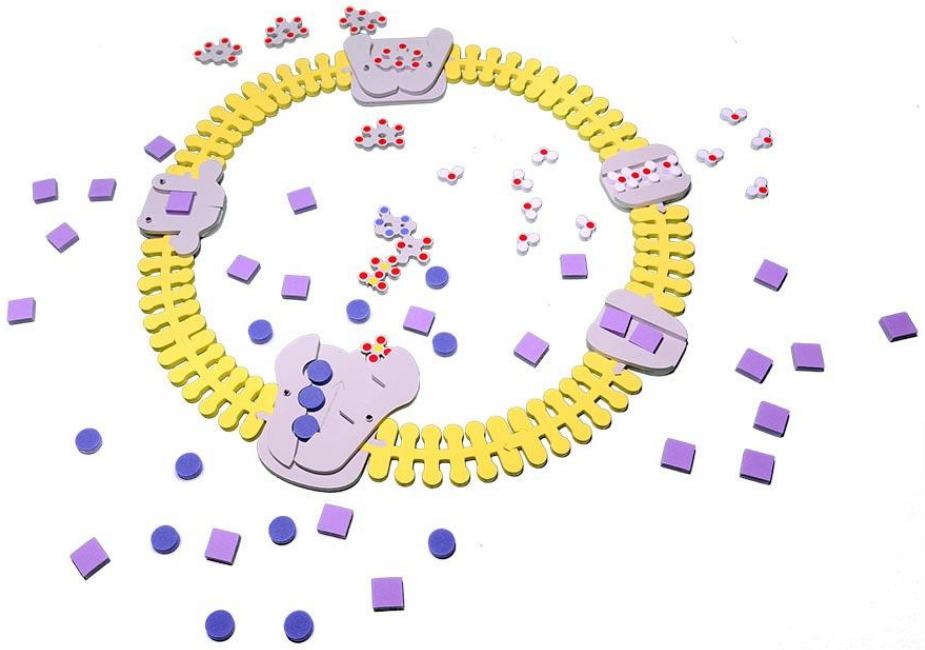


6. Original shape is restored, releasing K+ into the cell.





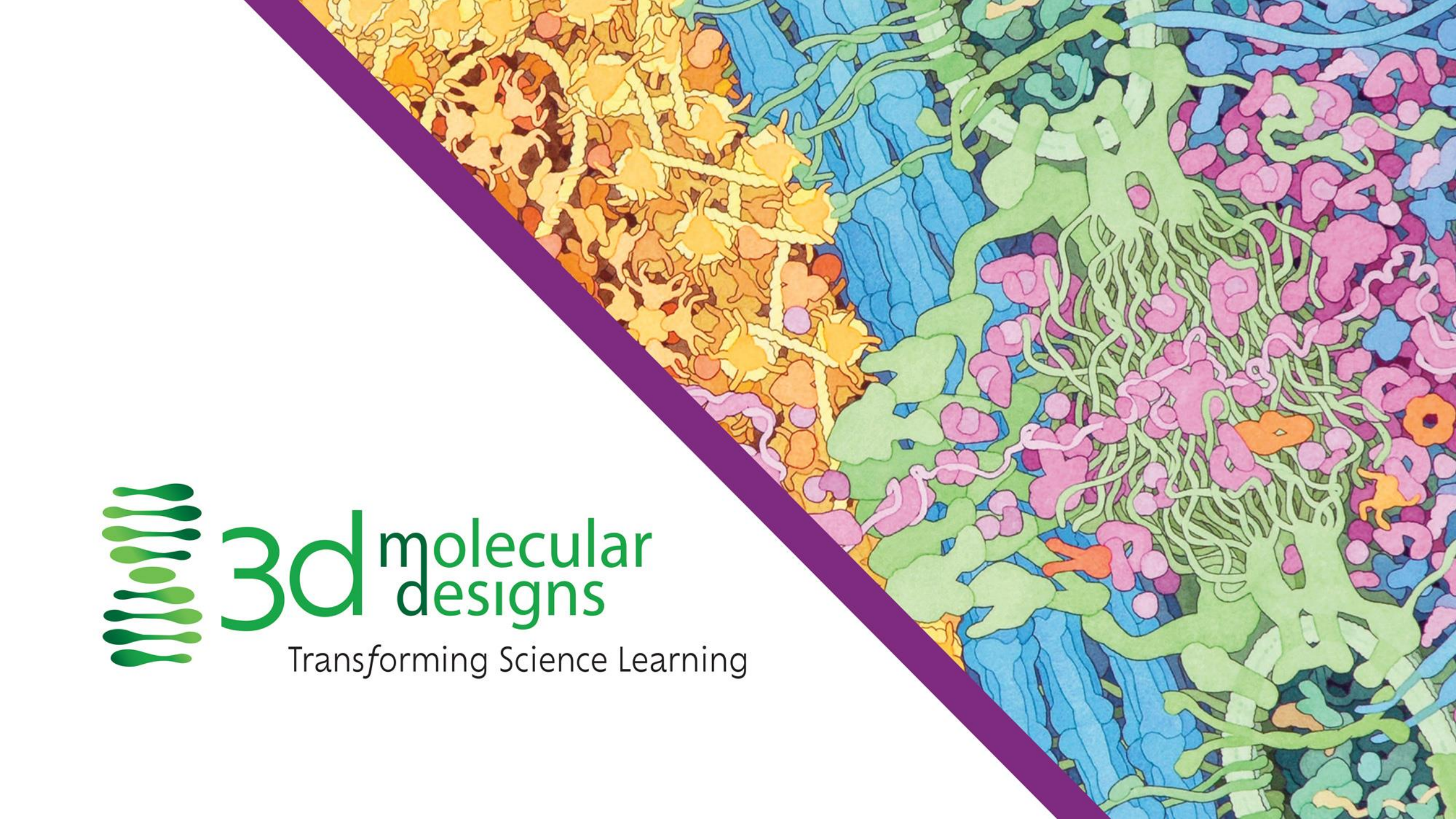
Final Diagnosis and Prognosis



How could this have been prevented? Write a letter explaining what occurred and what should be done in the future.

Workshop NGSS Connections

SEPs	CCCs	DCIs
Asking Questions	Patterns	MS-LS1-2
Developing and Using Models	Cause and effect	MS-LS1-3
Constructing Explanations	Structure and Function	HS-LS1-2
Engaging in an Argument from Evidence	Stability and Change	HS-LS1-3



3d molecular designs

Trans*forming* Science Learning