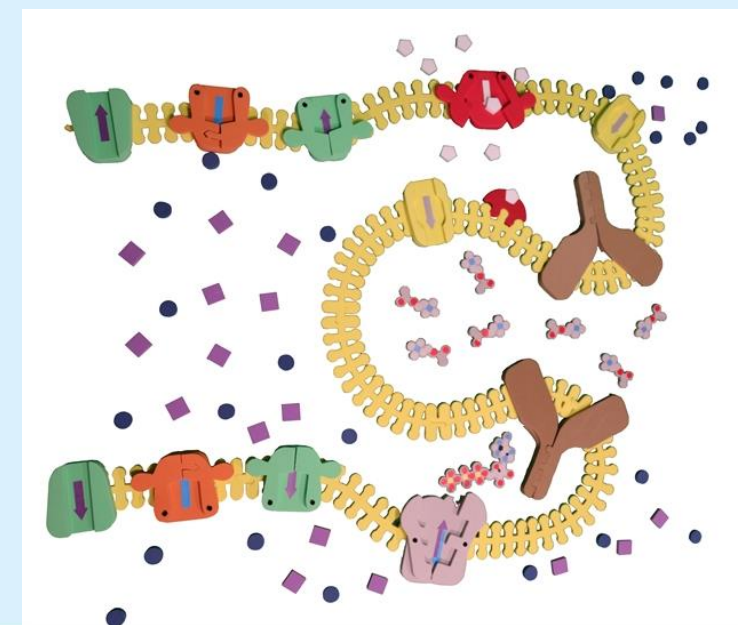
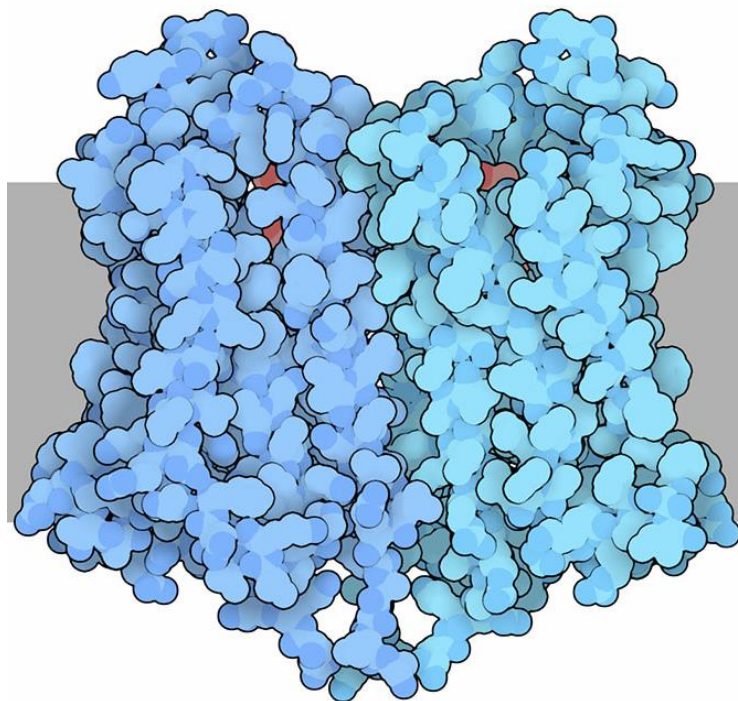


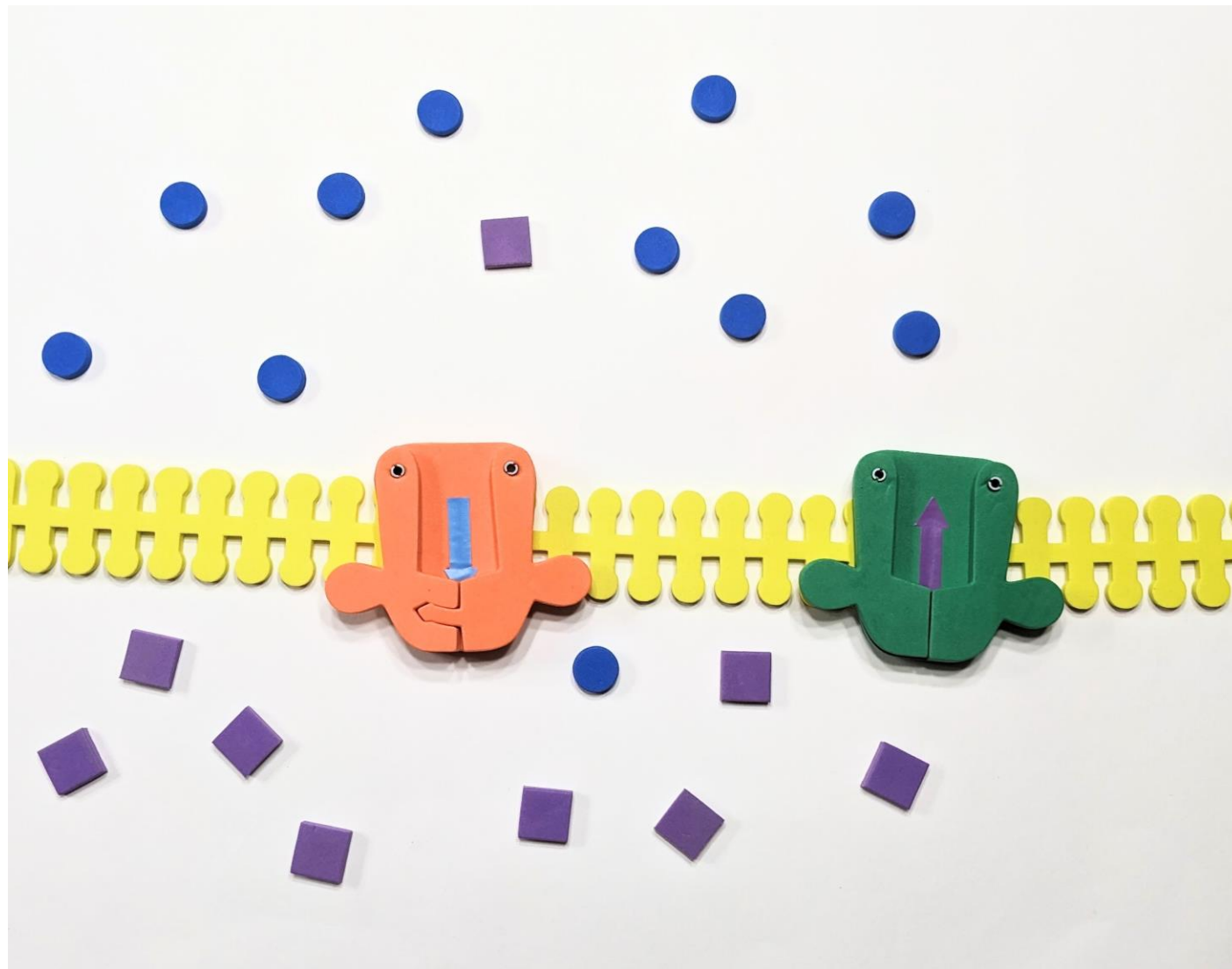
It's time to talk about it

Opioids, Narcan, and Mu-Opioid receptors interactions in the nervous system

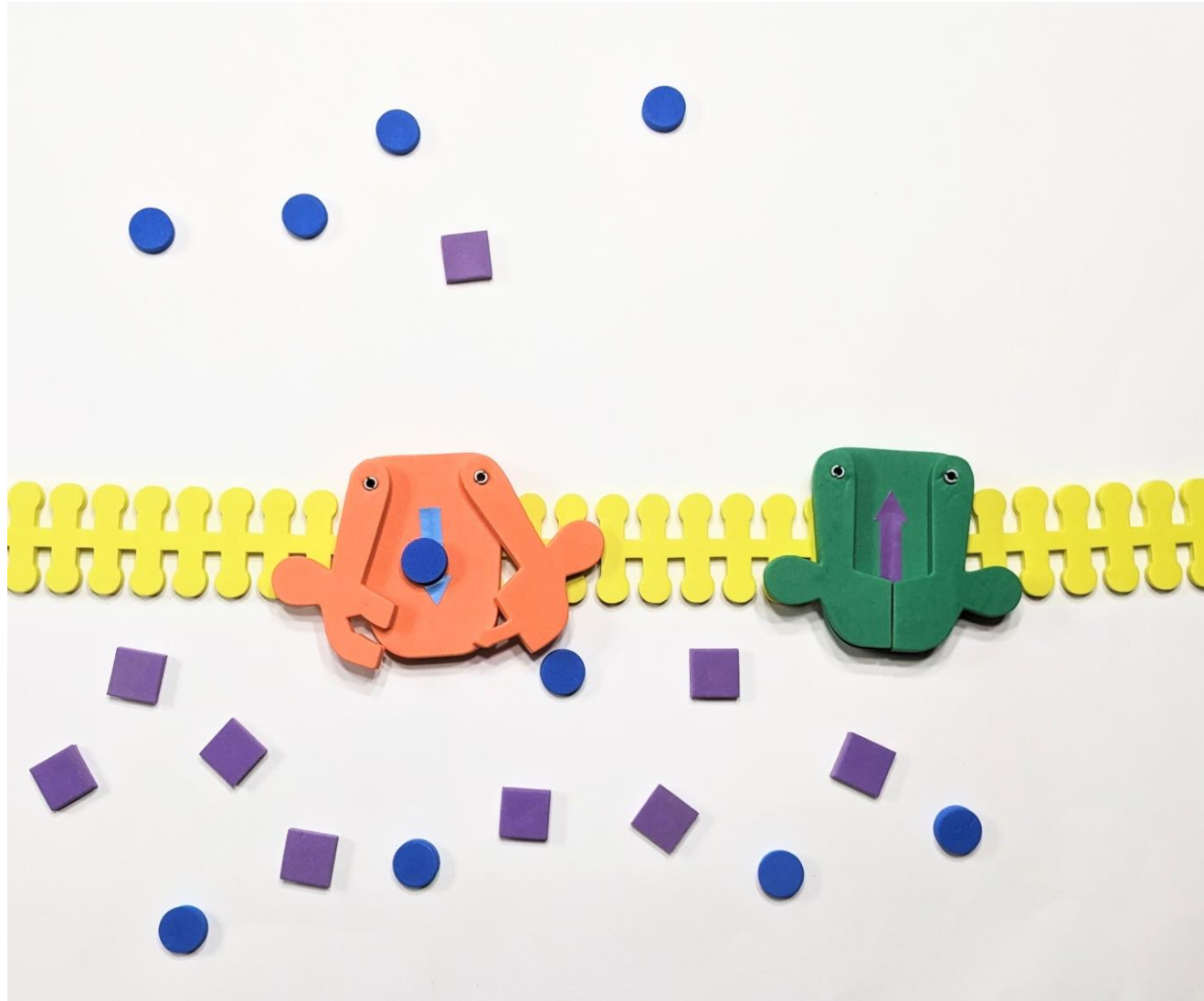
Ruth Hutson
Mark Arnholt



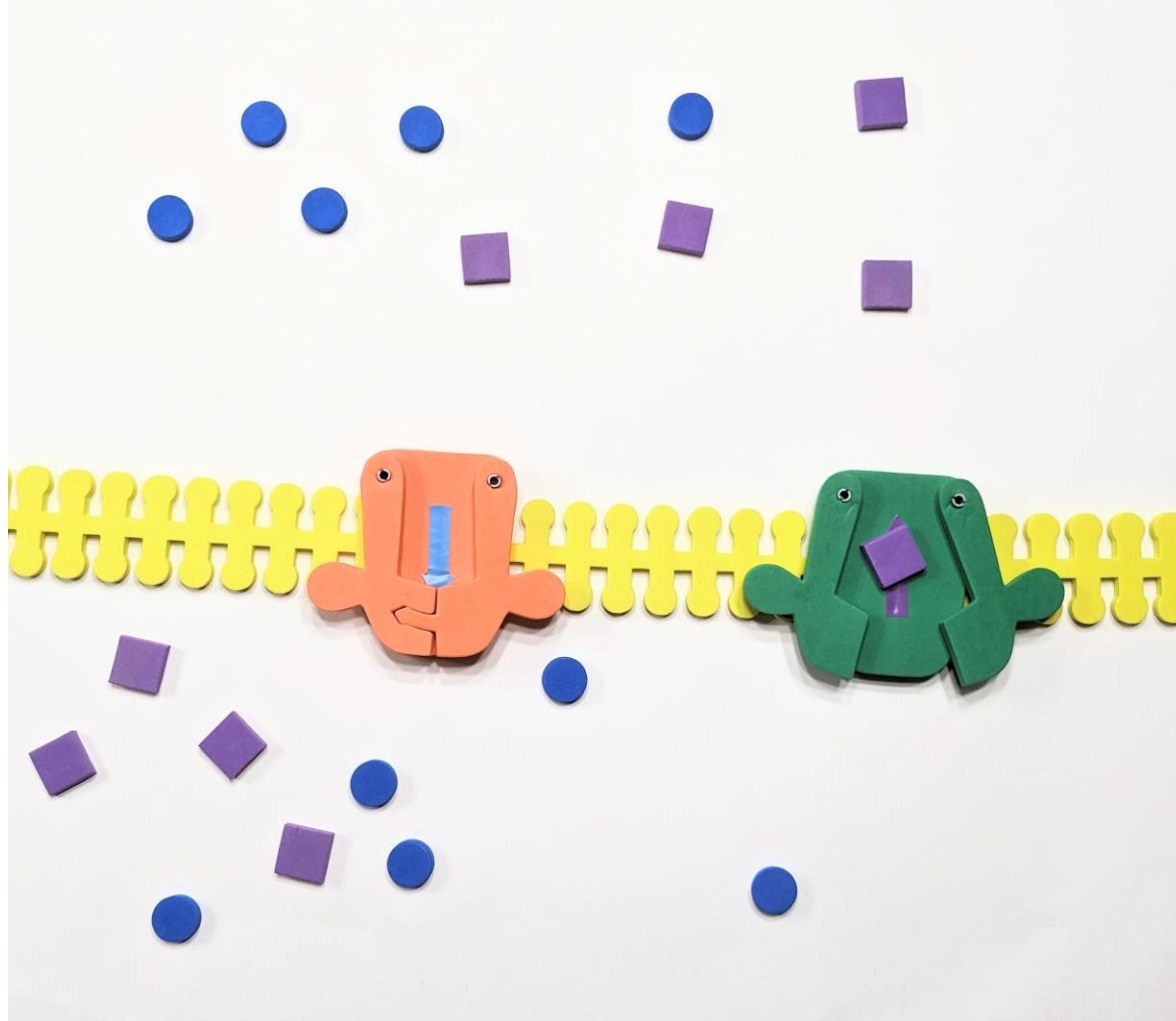
The Action Potential



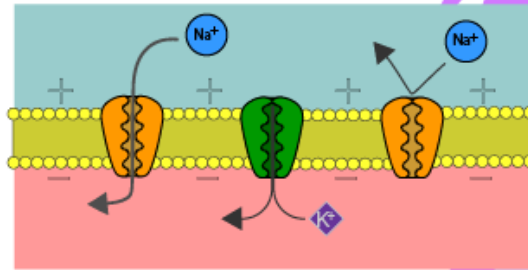
Sodium moves into the cell



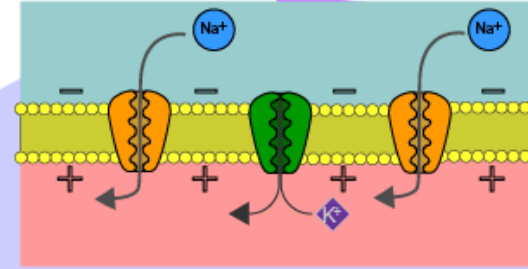
Potassium moves out!



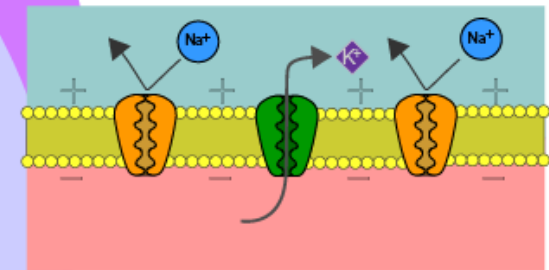
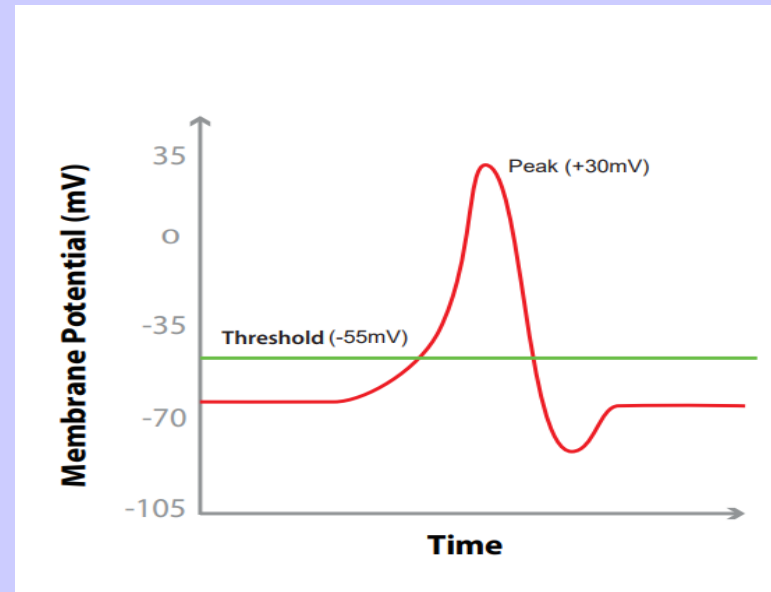
1 Resting state - The resting potential of the neuron is maintained by having the voltage gates closed in both Na⁺ and K⁺ channels.



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.

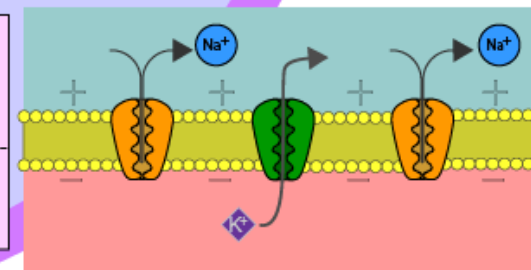
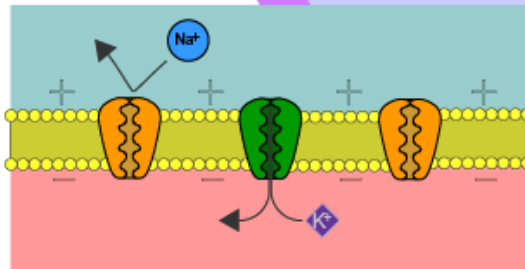


3 Rising phase - Most Na⁺ activation gates are now open, causing a large increase of Na⁺ ions inside the membrane. K⁺ channels remain closed. The higher concentration of Na⁺ ions make the inside of the membrane positive.



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.

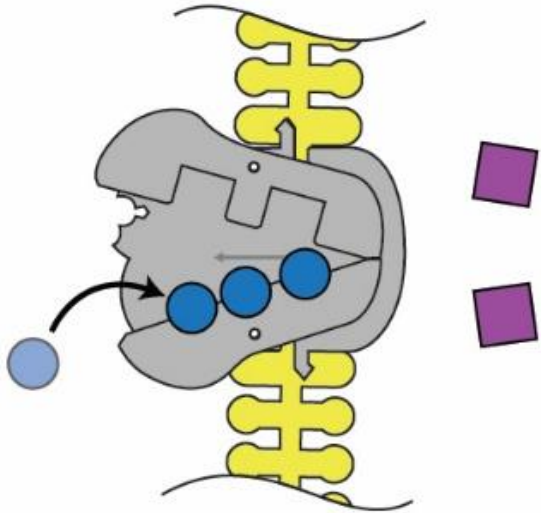
5 Undershoot - Activation and inactivation gates on Na⁺ channels are closed, but the gate on some K⁺ channels are still open. As the last K⁺ gates close, inactivation gates of Na⁺ channels open and the membrane is back at resting state.



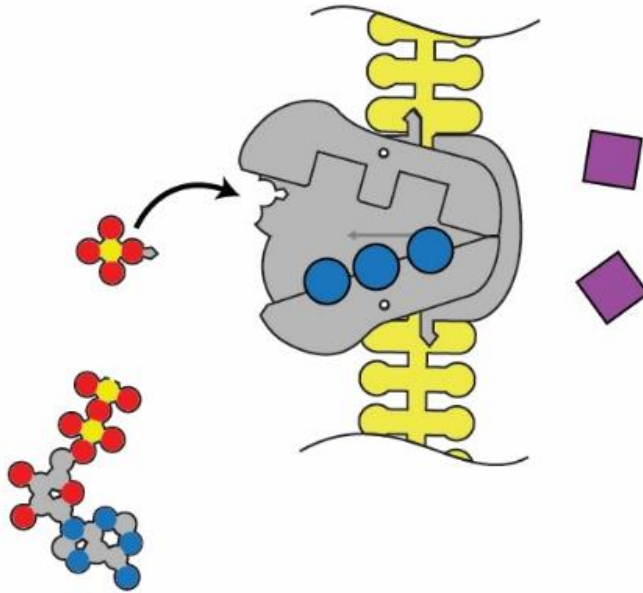
[Link](#)

How do we get back to a resting potential?

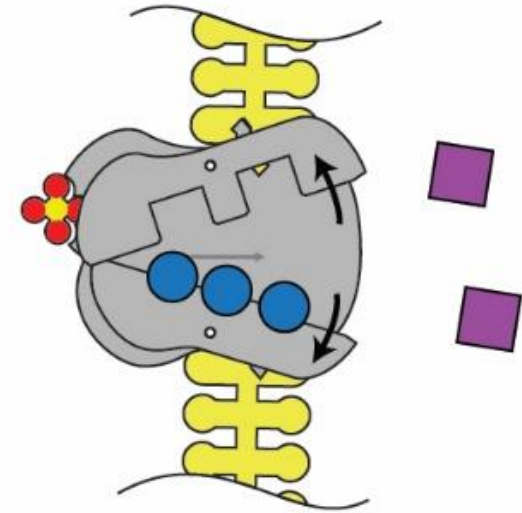
1. Sodium binds on intracellular side.



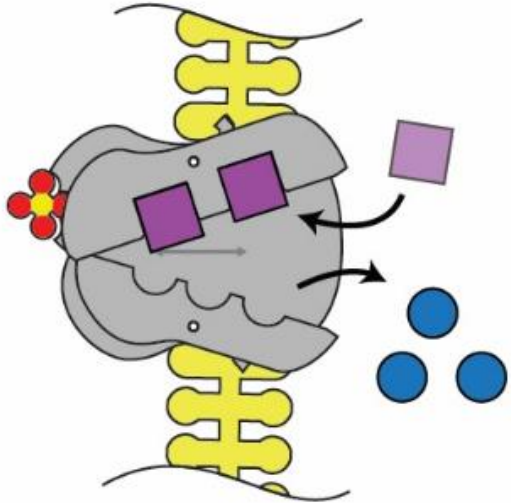
2. The pump is phosphorylated by ATP.



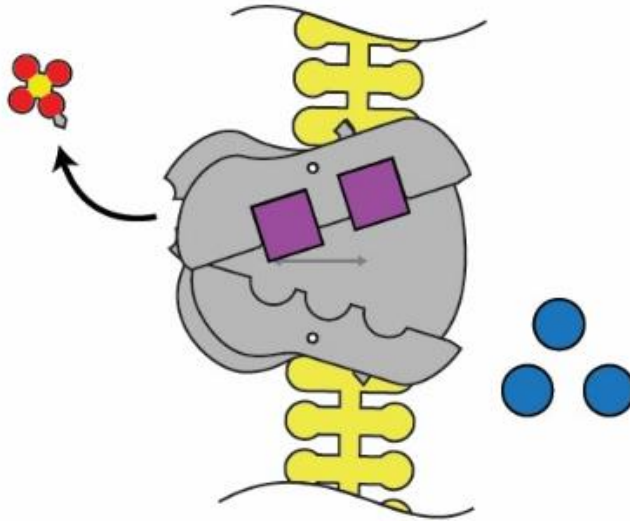
3. The pump shape changes, exposing the sodium to the extracellular space.



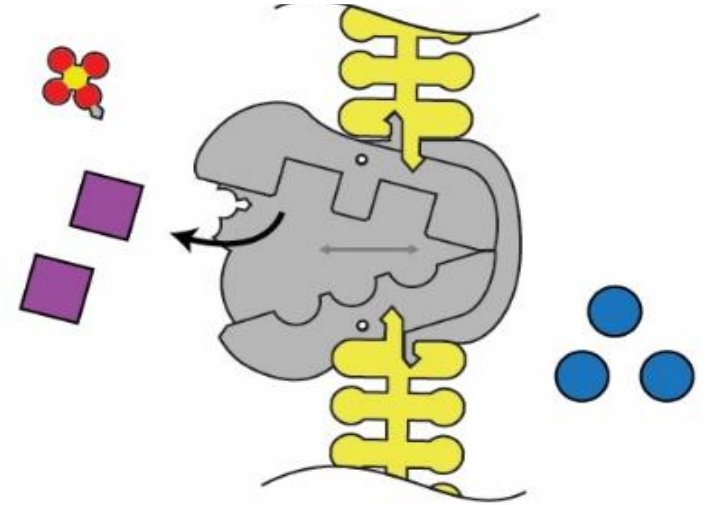
4. Binding affinity changes to release Na^+ , and take in K^+ .



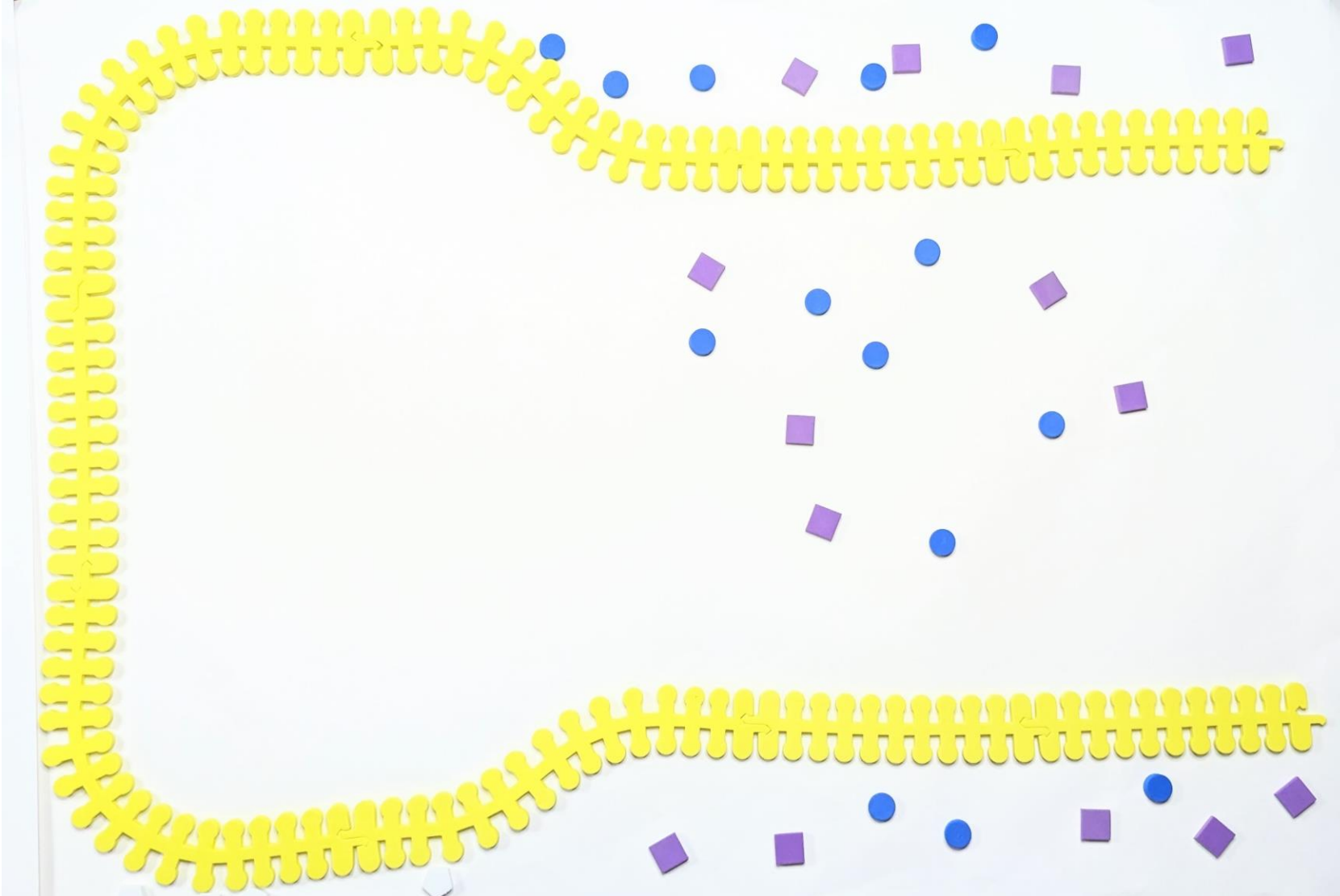
5. Phosphate detaches.



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



Snap Snares and Neurotransmitters



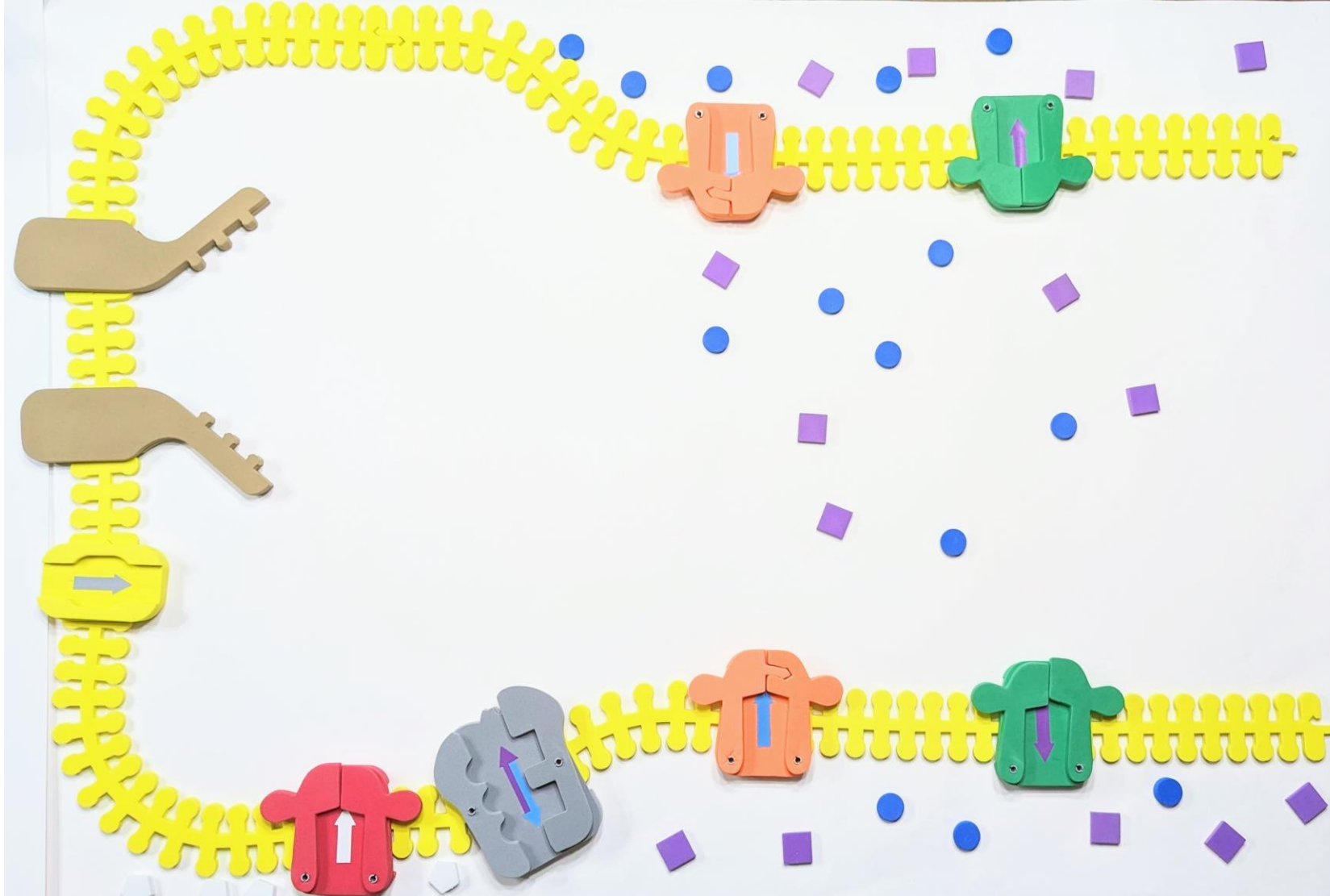
Make the neuronal
membrane with:

5 straight yellow
membrane pieces

2 wavy
yellow membrane
pieces

2 curved membrane
pieces

Snap Snares and Neurotransmitters



Add :

2 green voltage-gated potassium pumps

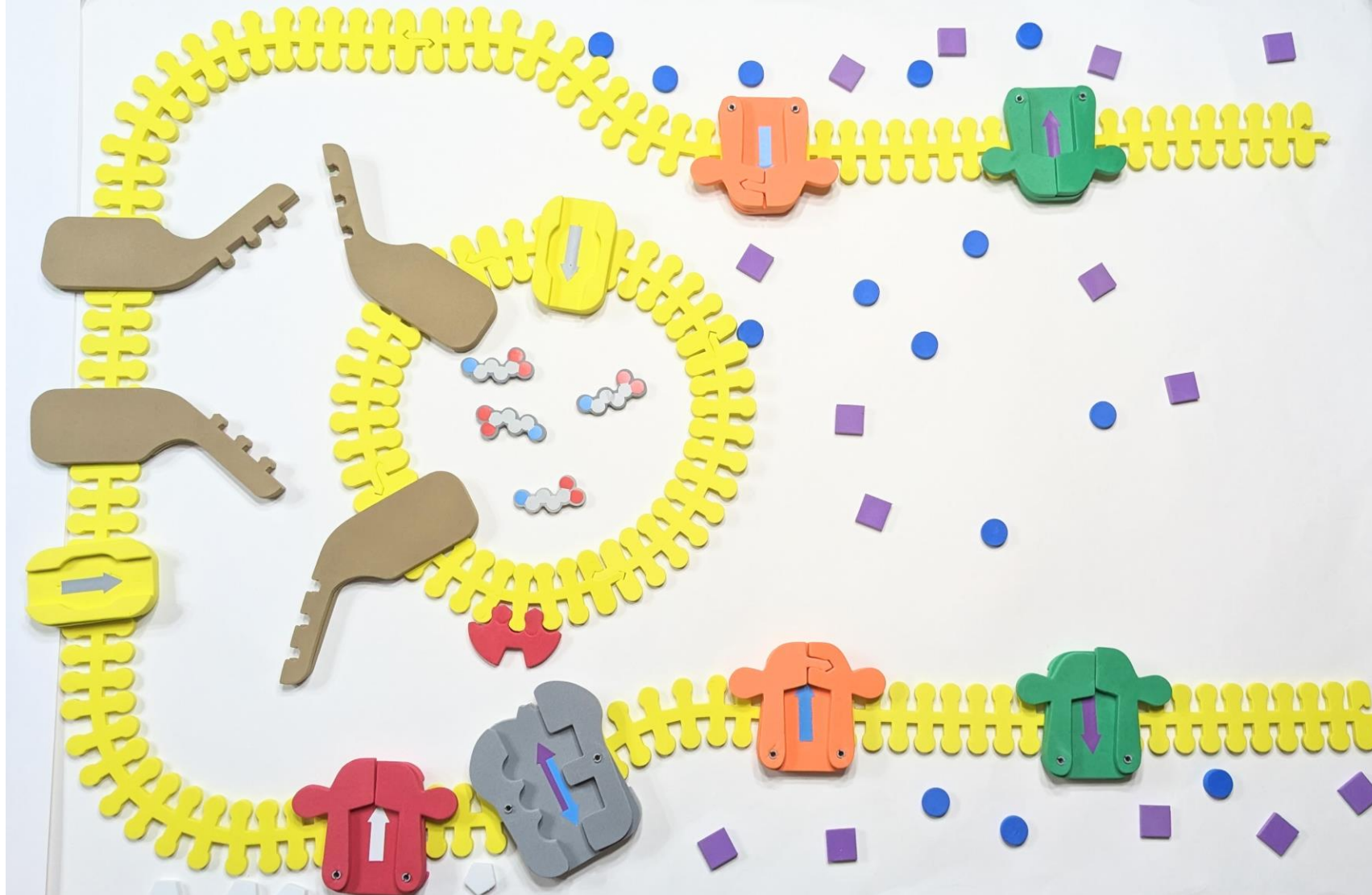
2 orange voltage-gated sodium pumps

1 red voltage gated calcium pump

1 brown SNAP/SNARE protein

1 yellow transport protein

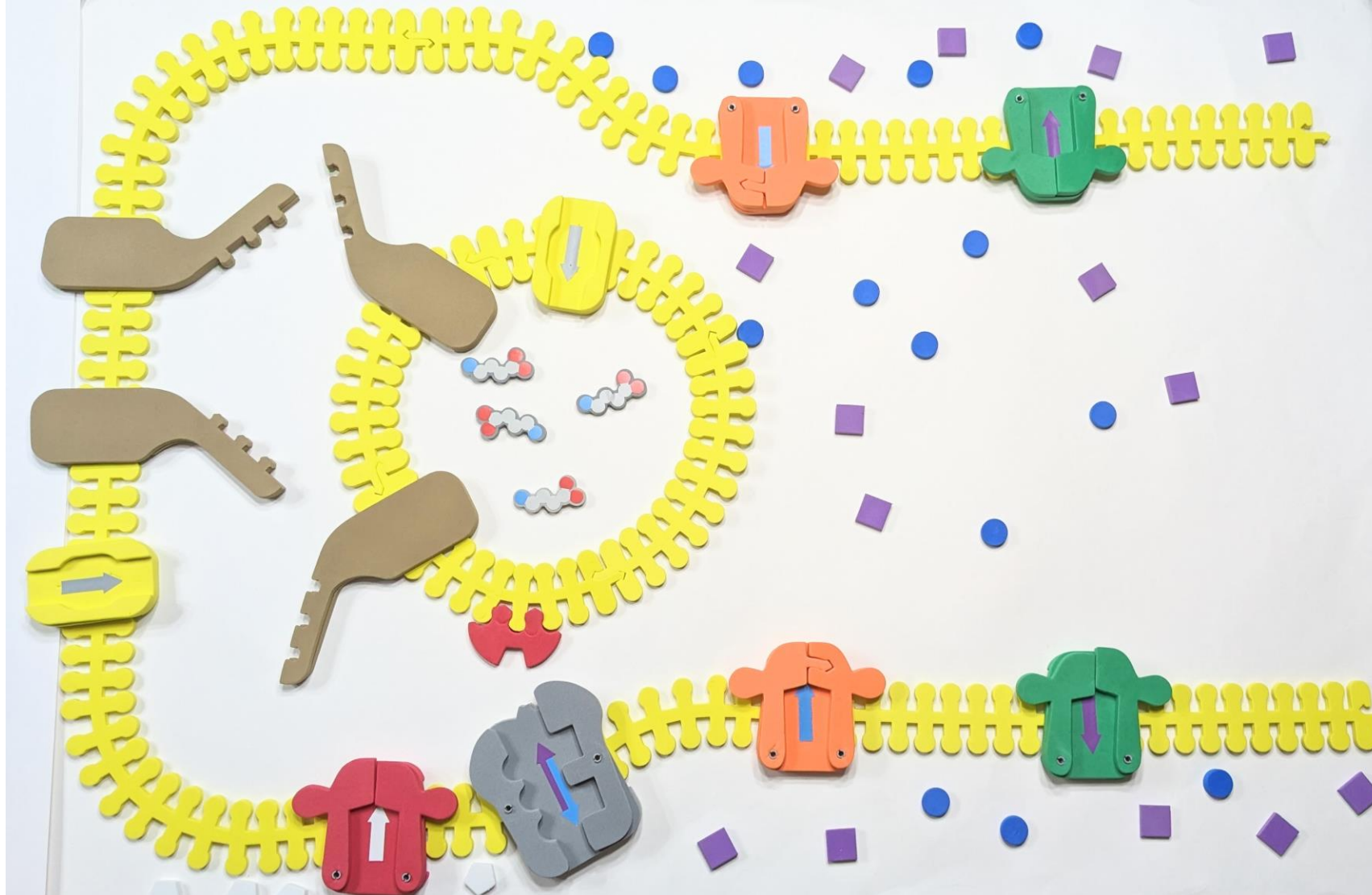
Snap Snares and Neurotransmitters



To make vesicle:
Join 4 straight
yellow membrane pieces

Then add
4 GABA
1 red calmodlin
1 yellow transport protein
1 brown SNAP/SNARE
protein

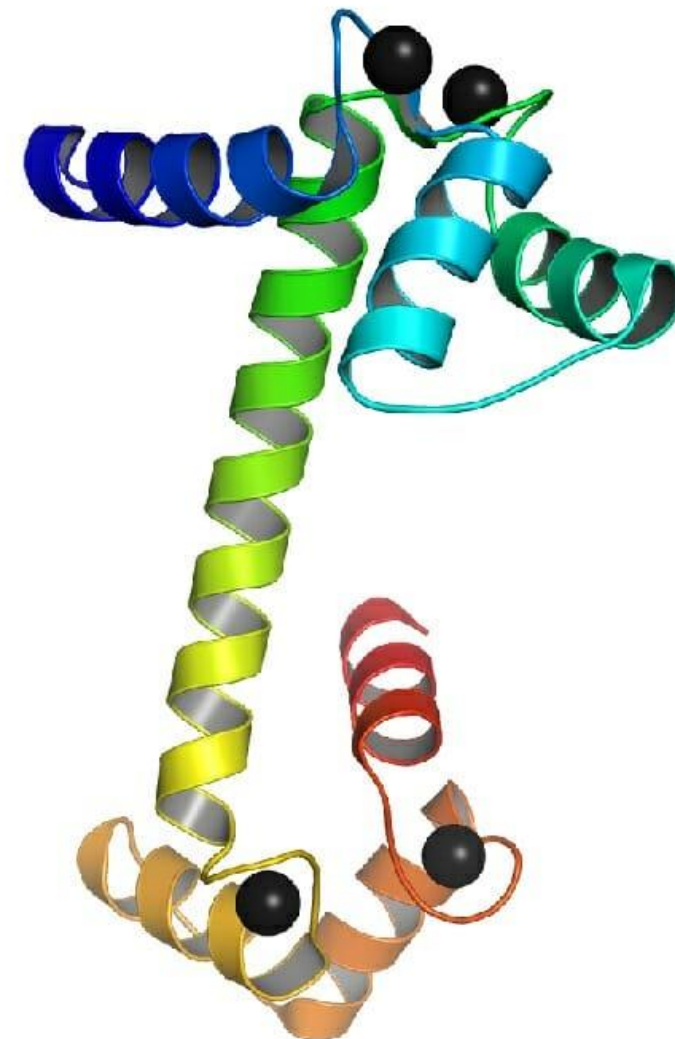
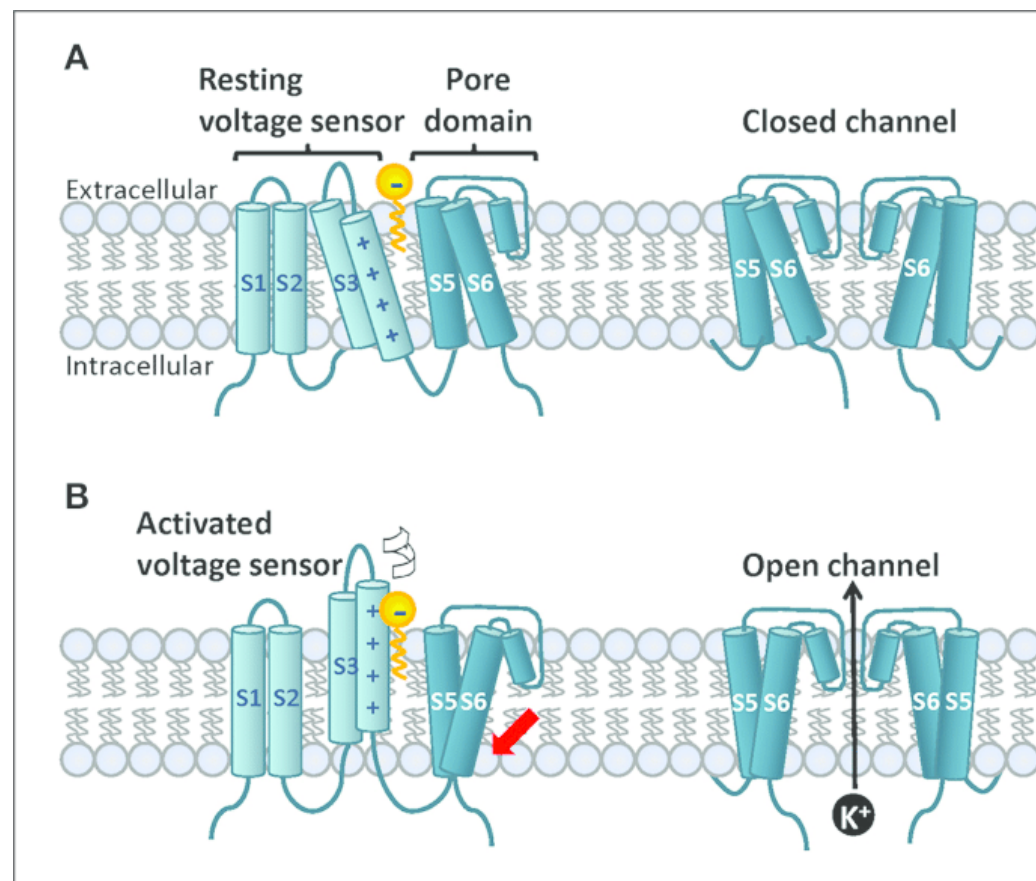
Snap Snares and Neurotransmitters



Let's model the GABAergic Synapse

- 1) Show action potential arriving at terminal end
- 2) Calcium channels open
What direction does Ca ion move?
Where do Ca ions bind?
- 3) SNAP/SNARE proteins interact to bring vesicle to membrane
- 4) GABA released into synaptic cleft.

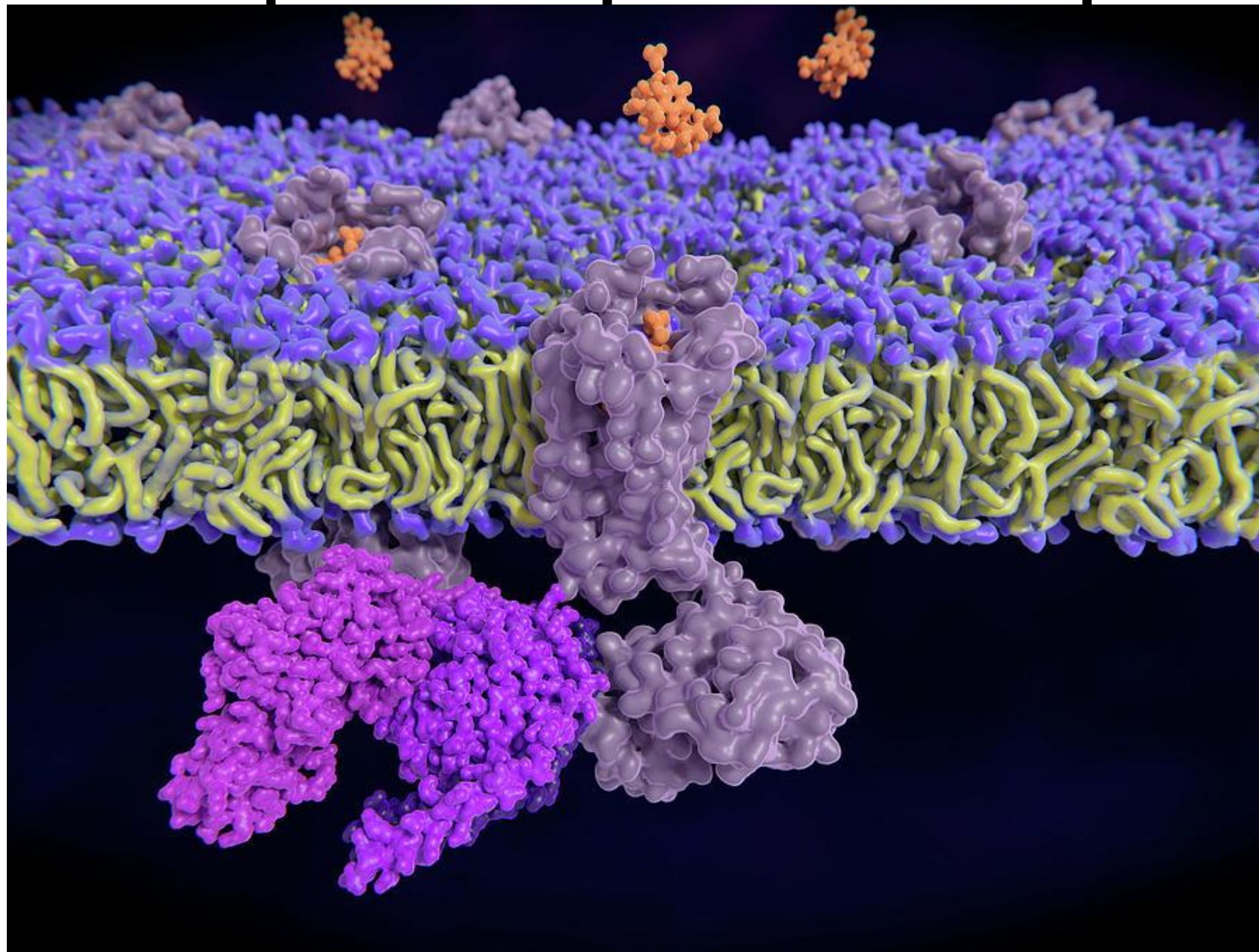
Calcium Channels and Calmodulin



Snap Snares and Neurotransmitters



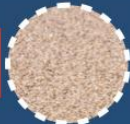
Mu- Opioid receptor and Enkephalins



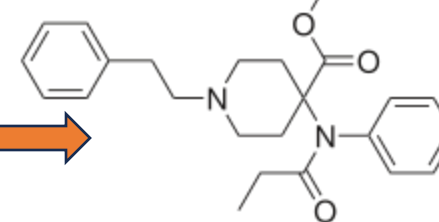
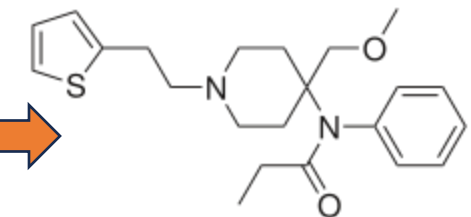
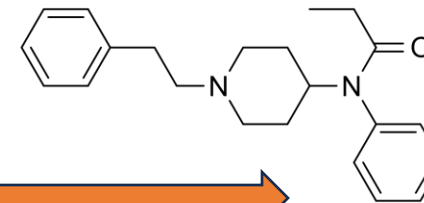
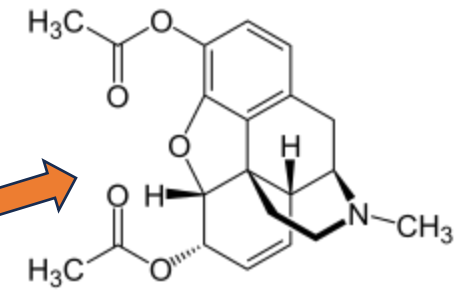
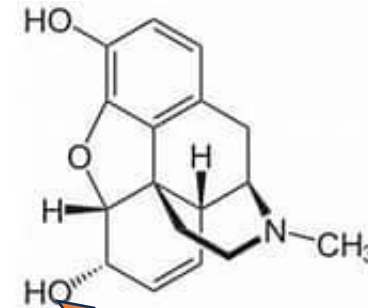
Opioid Analogs

Opioid Crisis

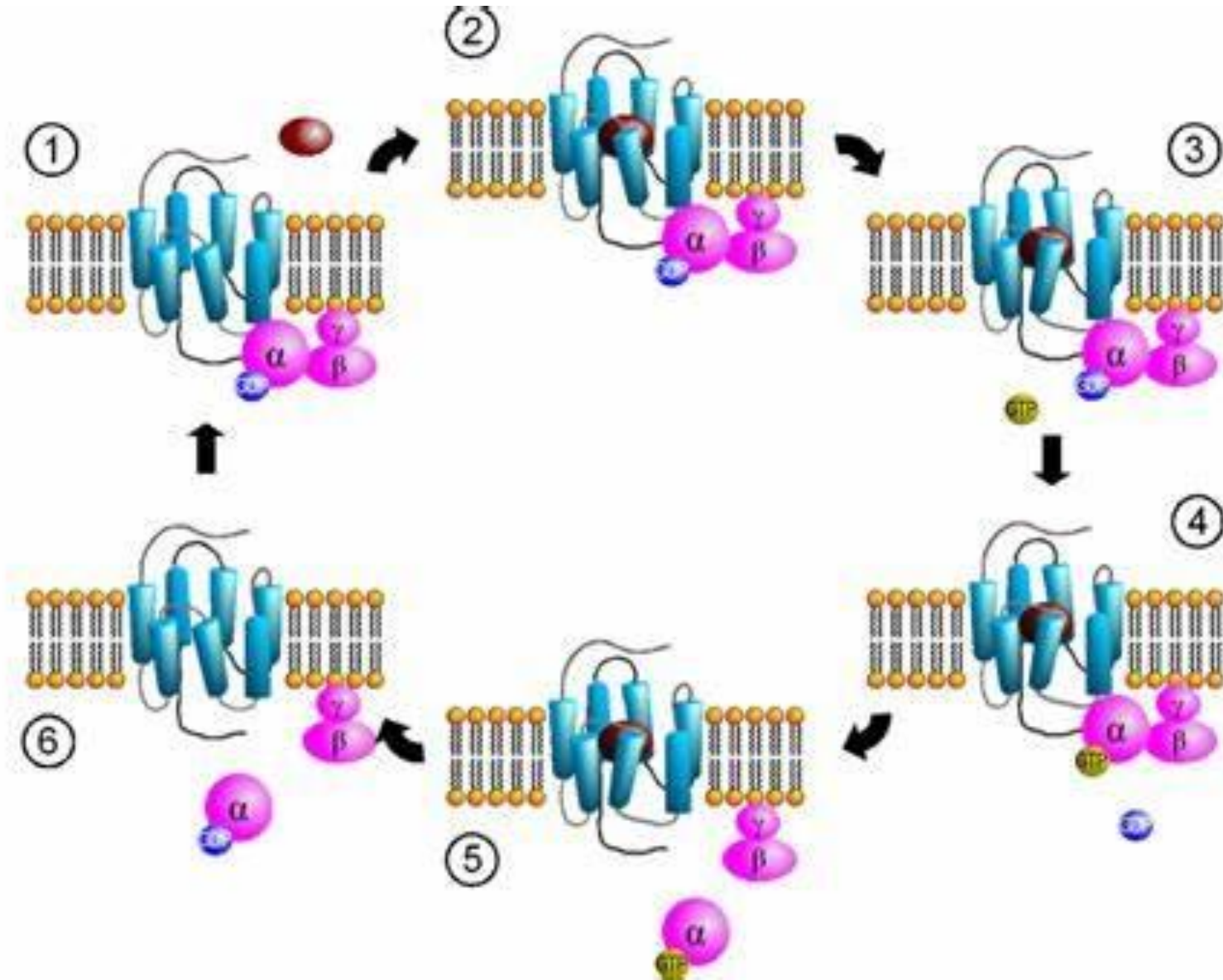
Lethal Opioid Doses

Opioid	FDA	Relative Potency	Lethal Dose
Morphine	✓	1x	1 Pea 
Heroin	✓	2x	1 Sunflower Seed 
Fentanyl	✓	100x	1 Sesame Seed 
Sufentanil	✓	500x	1 Grain of Sand 
Carfentanil	✗	10,000x	0.5 Grains of Salt 

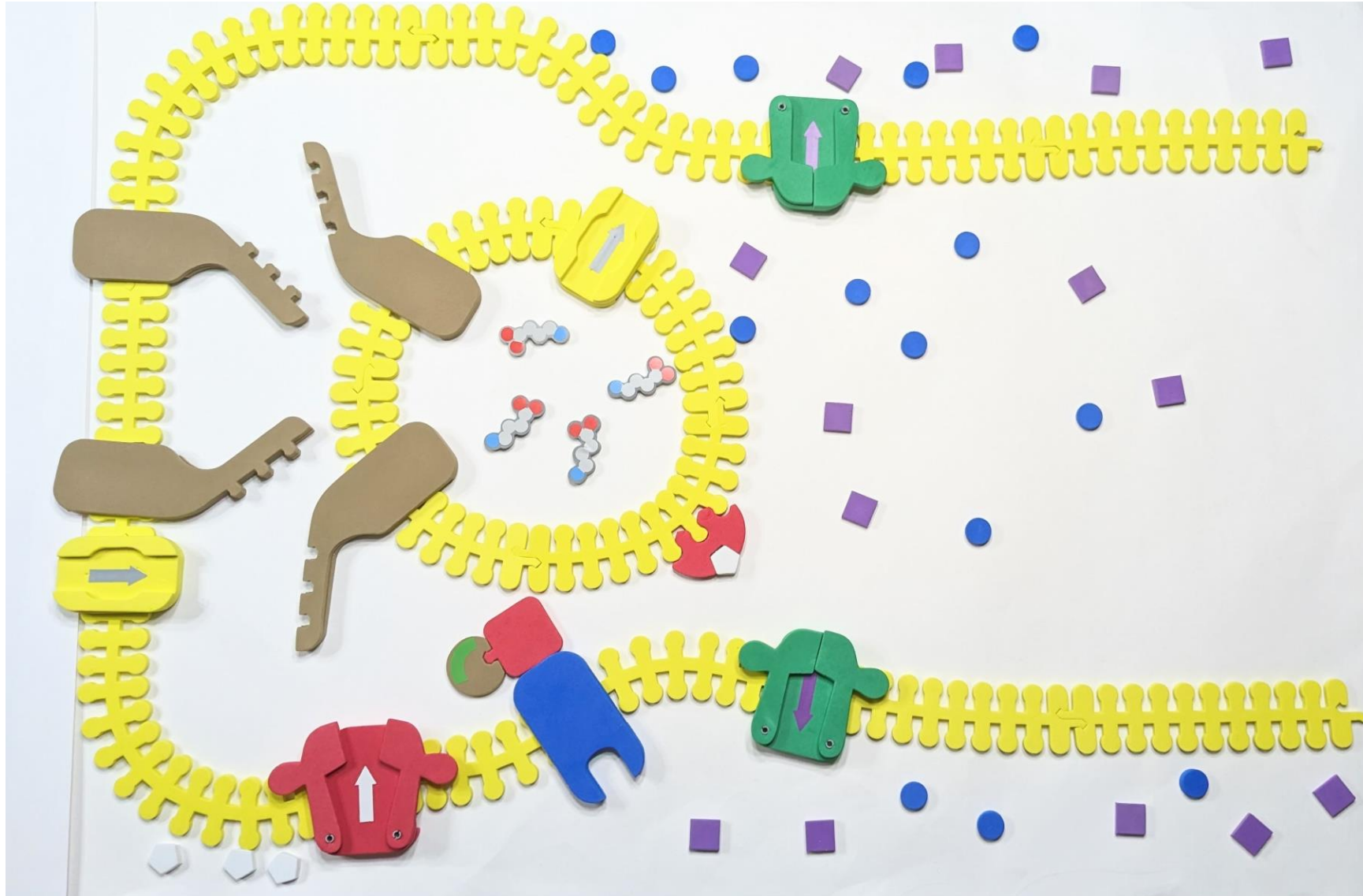
Clearvue Health



G-coupled proteins

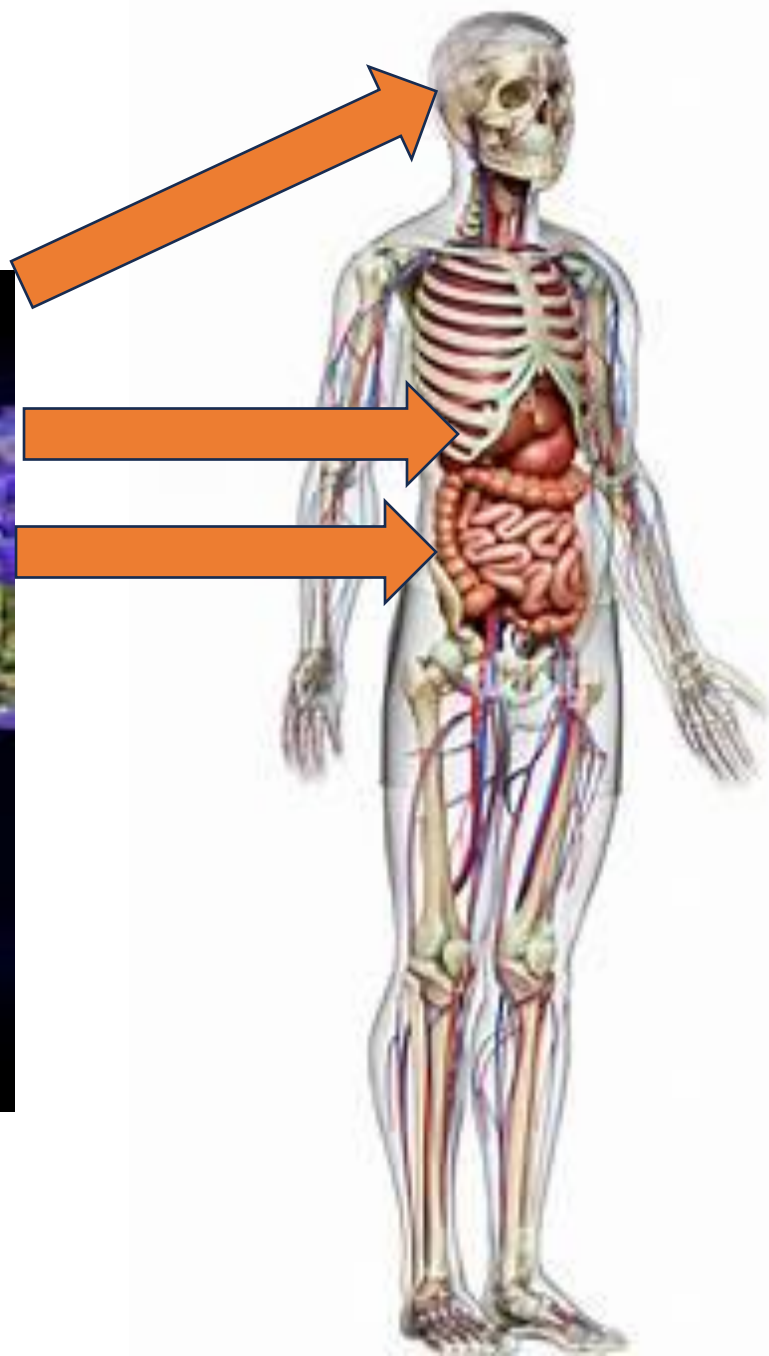
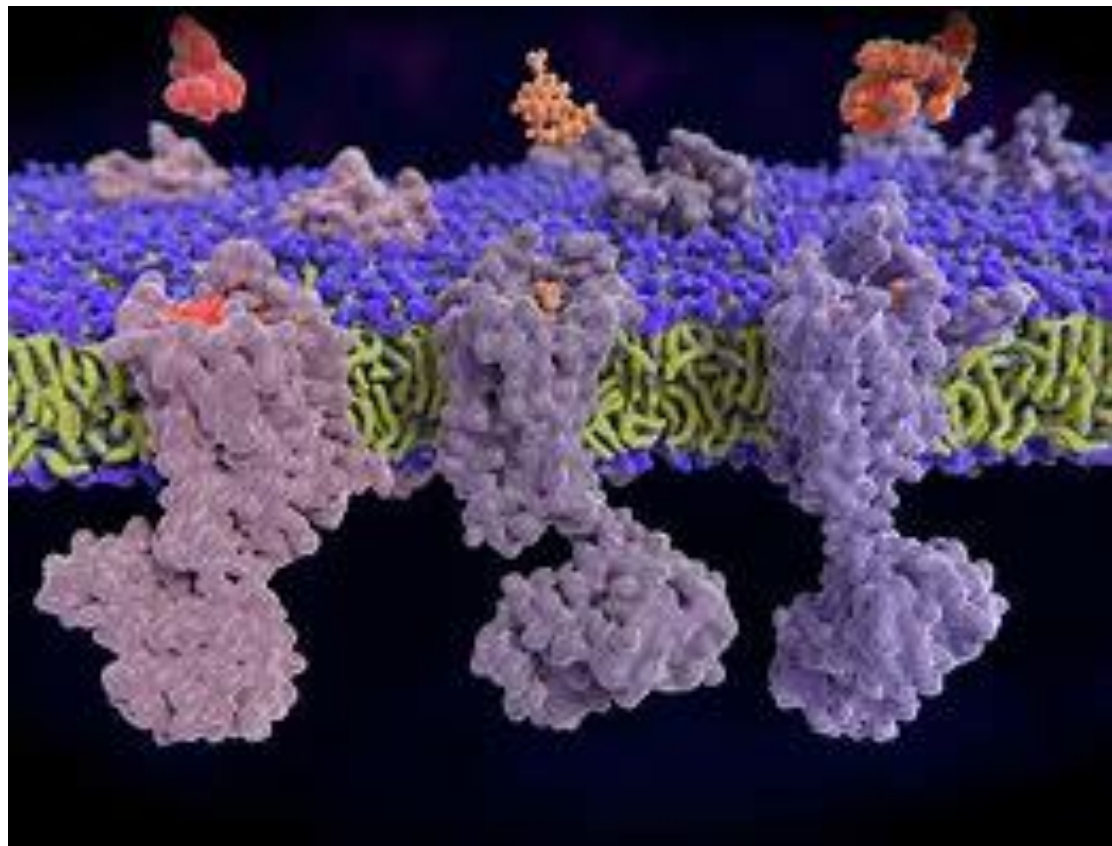


Let's model this!

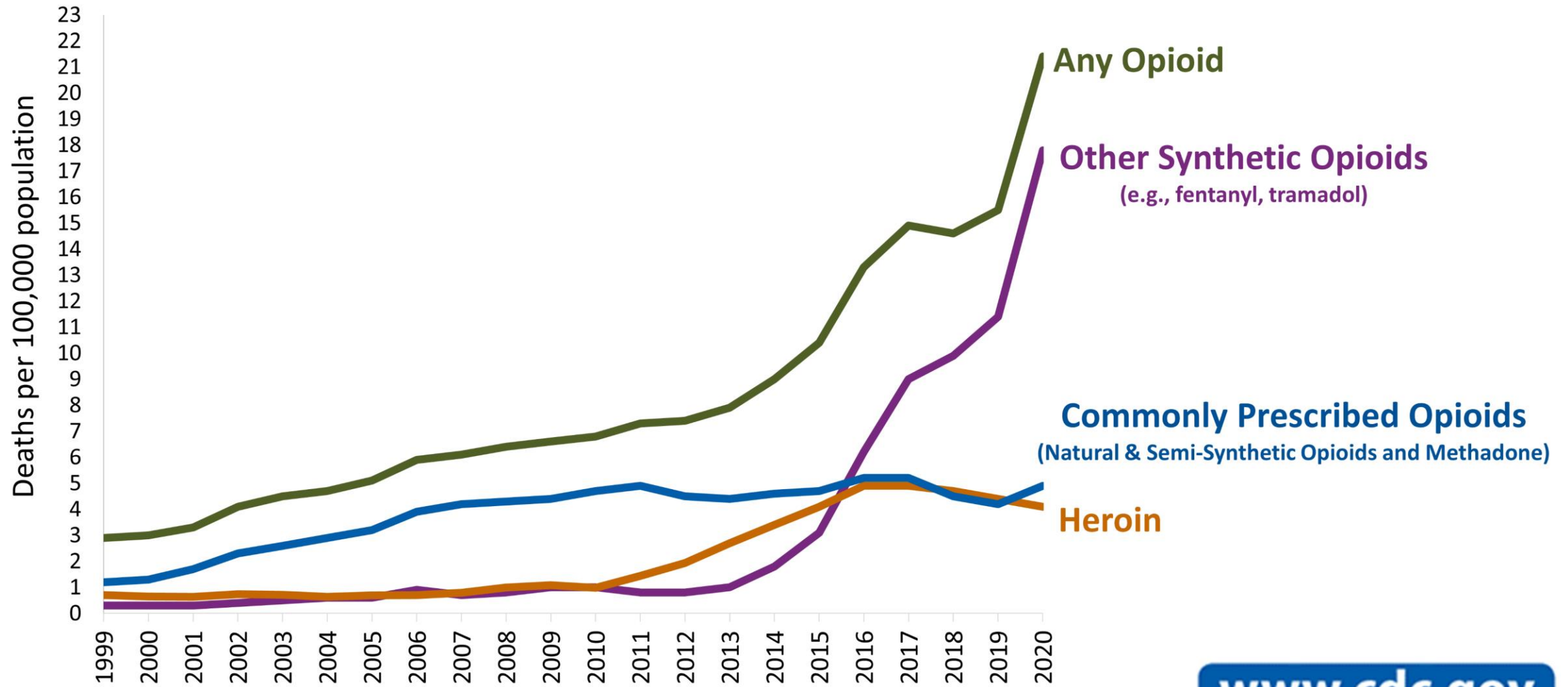


Downstream interactions





Overdose Death Rates Involving Opioids, by Type, United States, 1999-2020



SOURCE: CDC/NCHS, National Vital Statistics System, Mortality. CDC WONDER, Atlanta, GA: US Department of Health and Human Services, CDC; 2020. <https://wonder.cdc.gov/>.

Naloxone



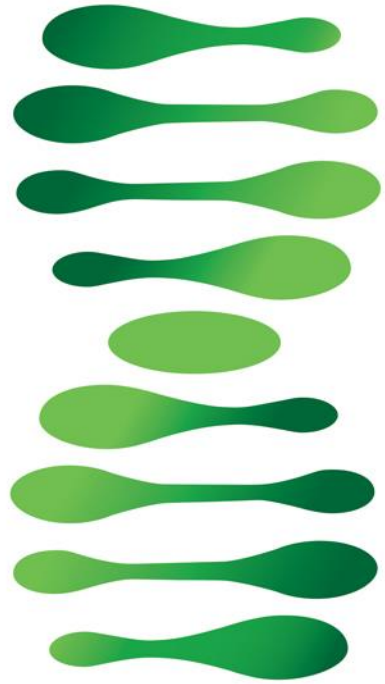


Scan this QR code and fill out our survey!



Show me your DNA molecule image
and I'll give you a model with AR
enhancement as a thank-you gift!





Transforming Science Learning

