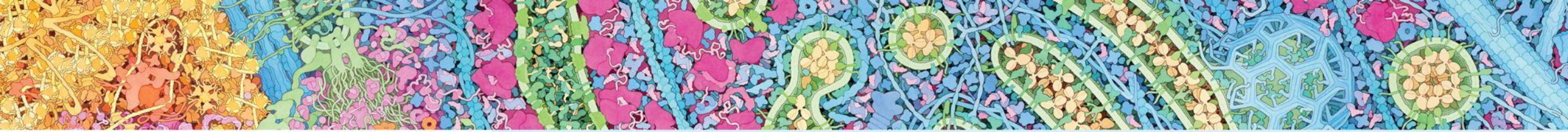

3d molecular designs
Transforming Science Learning

Teaching the Molecular Mechanisms of Addiction with Physical Models

Link to slides

2023 NBTA National Conference

Alan Allmen, NBCT
Whitney Young Magnet High School
Chicago Public Schools

https://tinyurl.com/2023nbta-addiction

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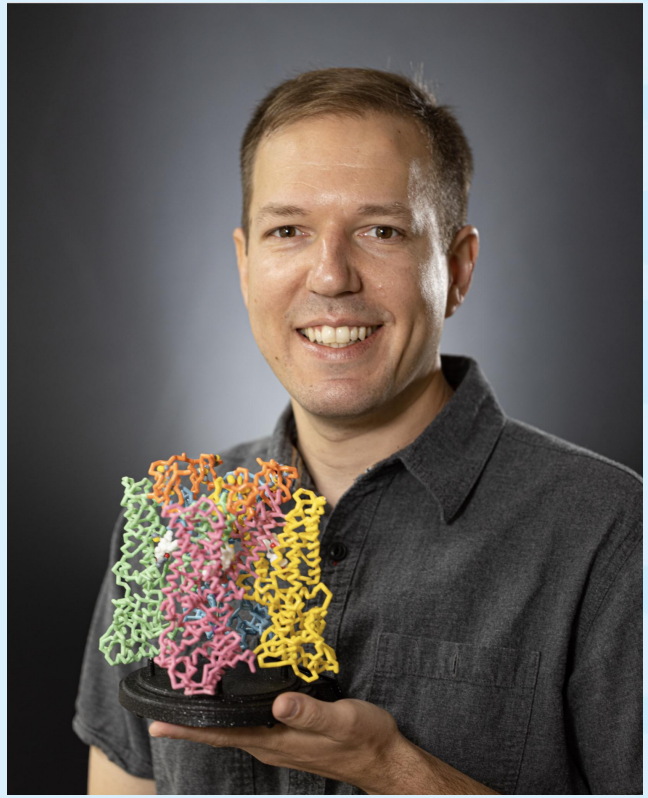
Transforming Science Learning

Alan Allmen, NBCT
Whitney M Young Magnet High School
Chicago, IL

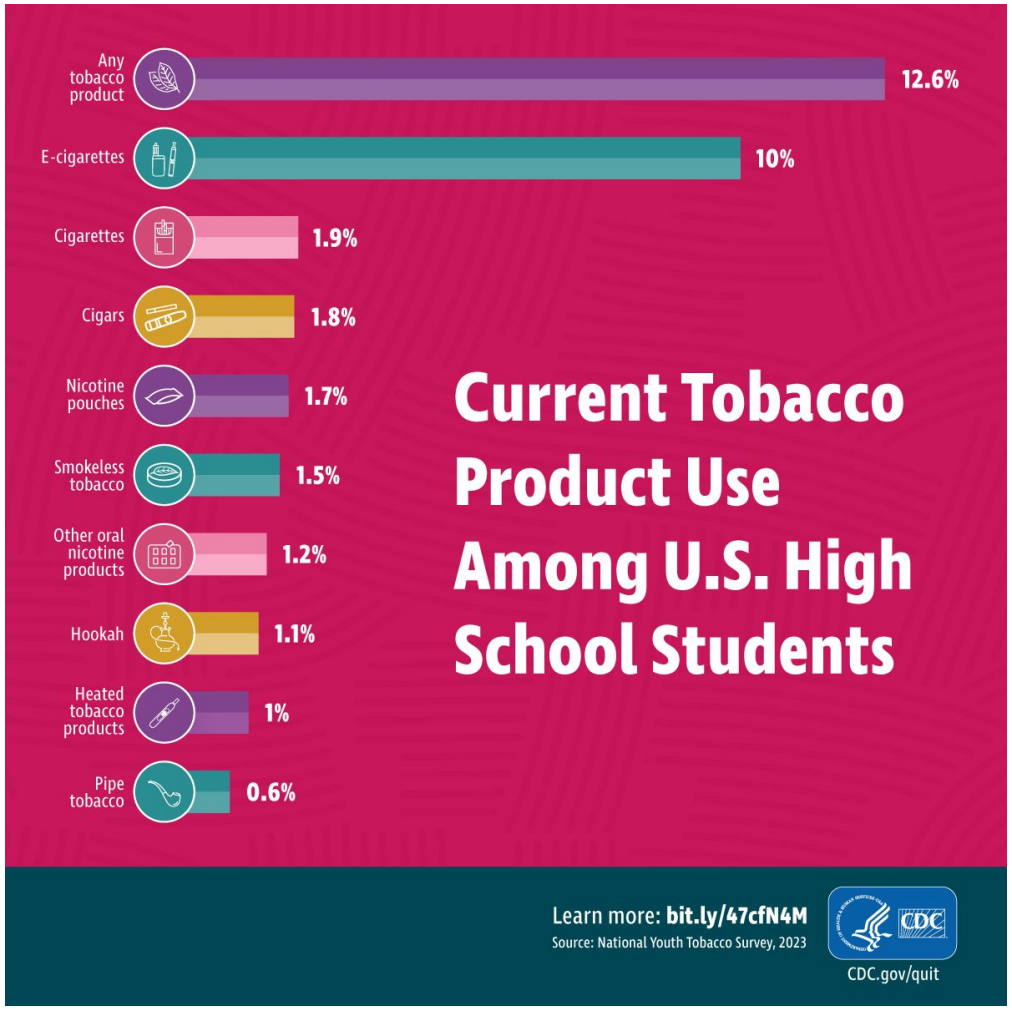


TRPV1 receptor

Workshop Learning Goals

- Experience the value of physical modeling of biological processes
- Model the basic biology of synaptic transmission
- Model the impact of psychoactive drugs on synaptic transmission

Why teach addiction pathways?



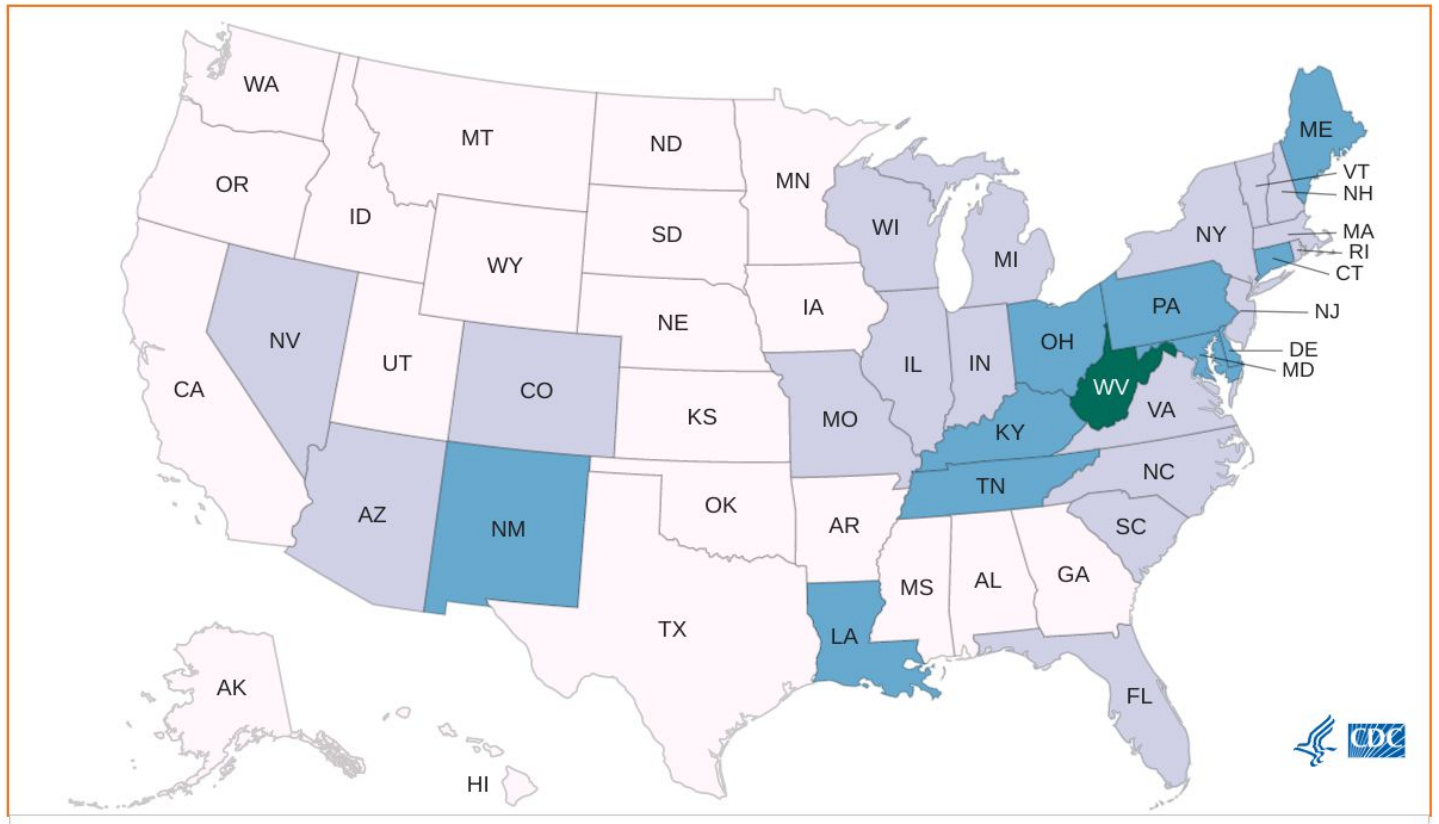
In 2023, 1 in 10 teens reported using e-cigarettes in the past month.

12.6% percent of teens reported using tobacco products containing nicotine.

Source: CDC

Why teach addiction pathways?

Drug Overdose Mortality by State



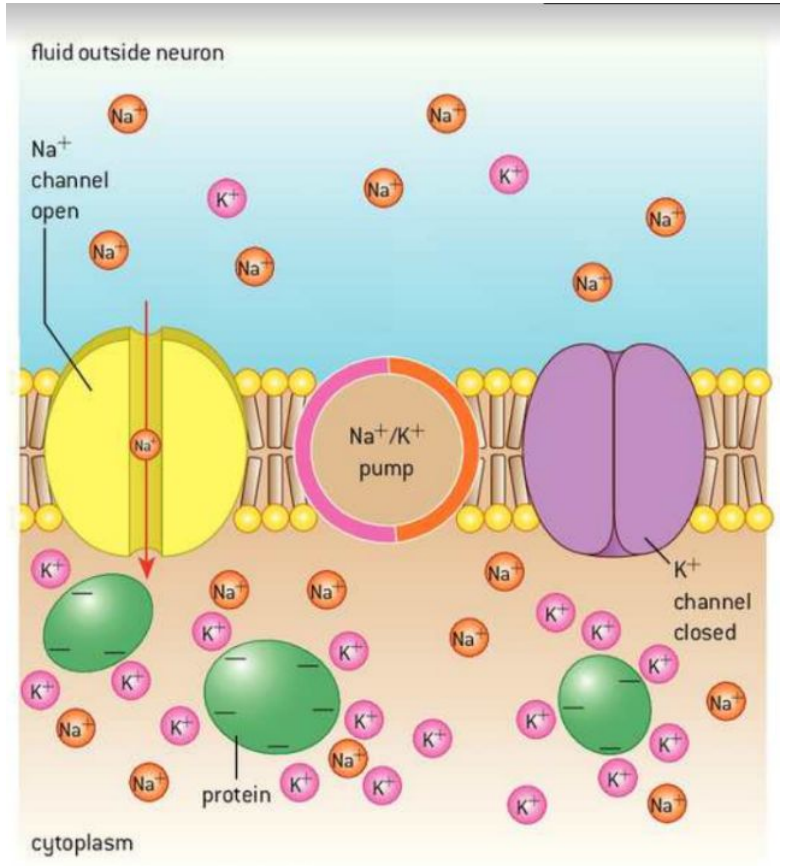
Illinois saw 3,717 drug overdose deaths in 2021

Death rates, particularly due to opioids, have been rising

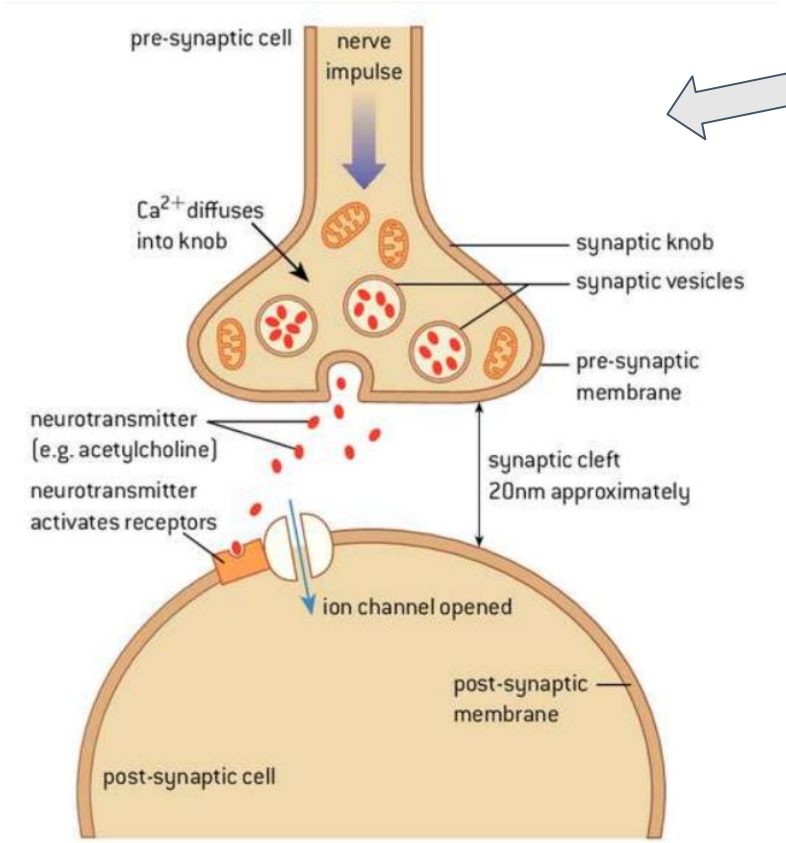
Among leading causes of death for teenagers and young adults

Sources: CDC, IDPH

Why physical models?



▲ Figure 6 Neuron depolarizing

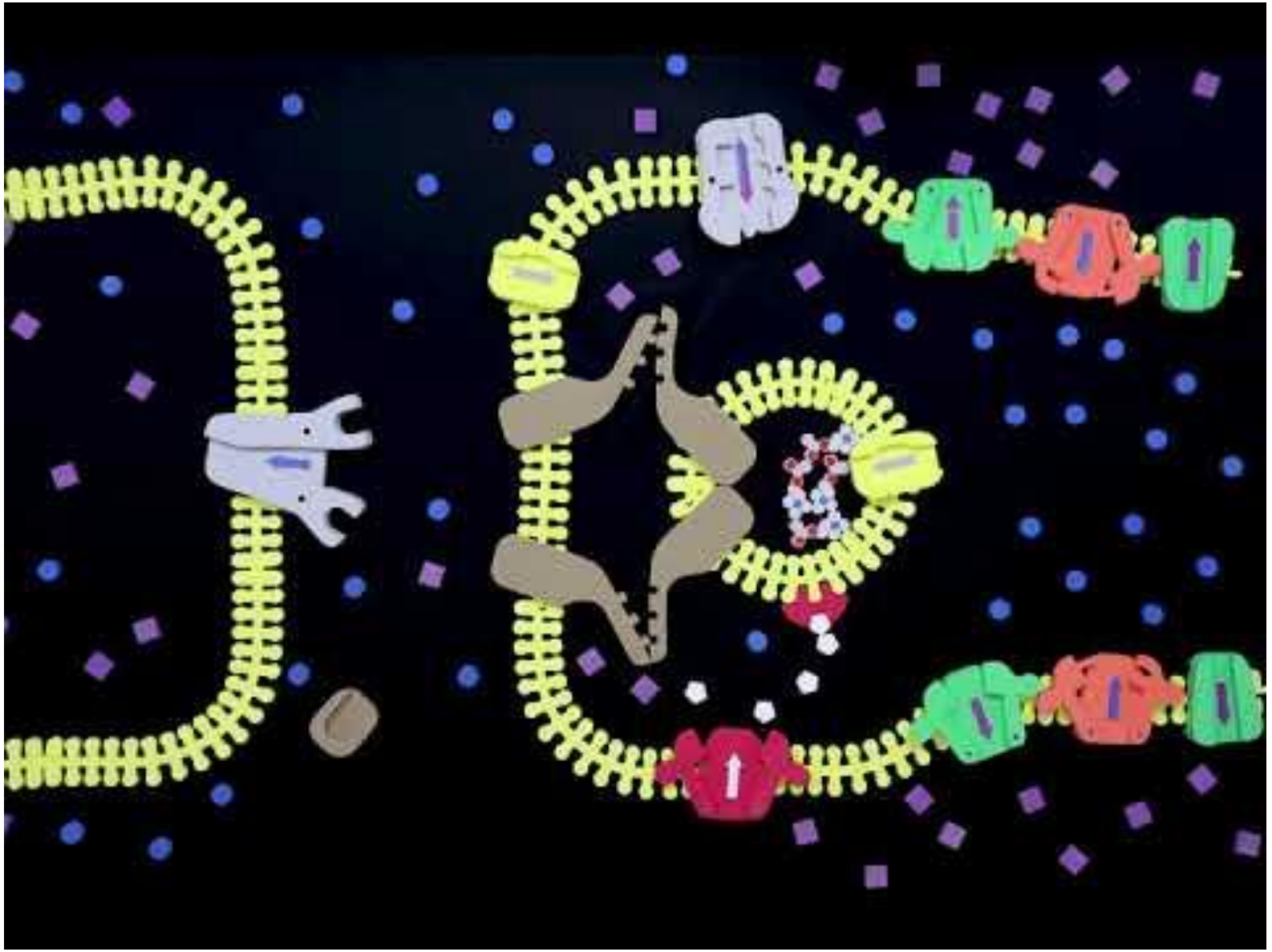


▲ Figure 14 A nerve impulse is propagated across a synapse by the release, diffusion and post-synaptic binding of neurotransmitter

Sample textbook pictures of synaptic transmission

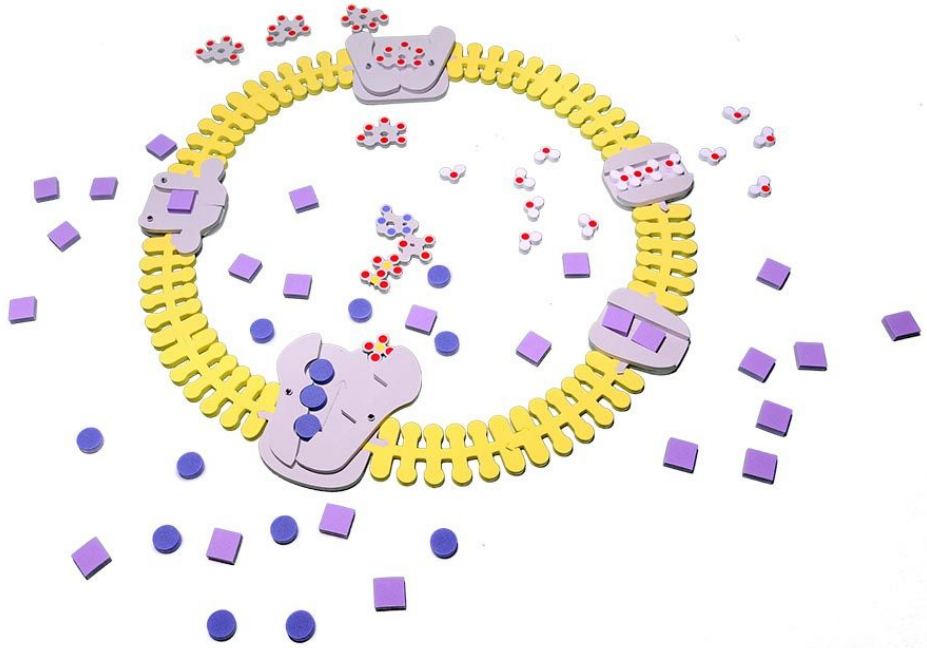
Physical models

- dynamic
- interactive
- adaptable



Stop-motion animation of synaptic transmission in a cholinergic synapse

Previously taught:



Membrane transport with the **Phospholipid and Membrane Transport Kit**

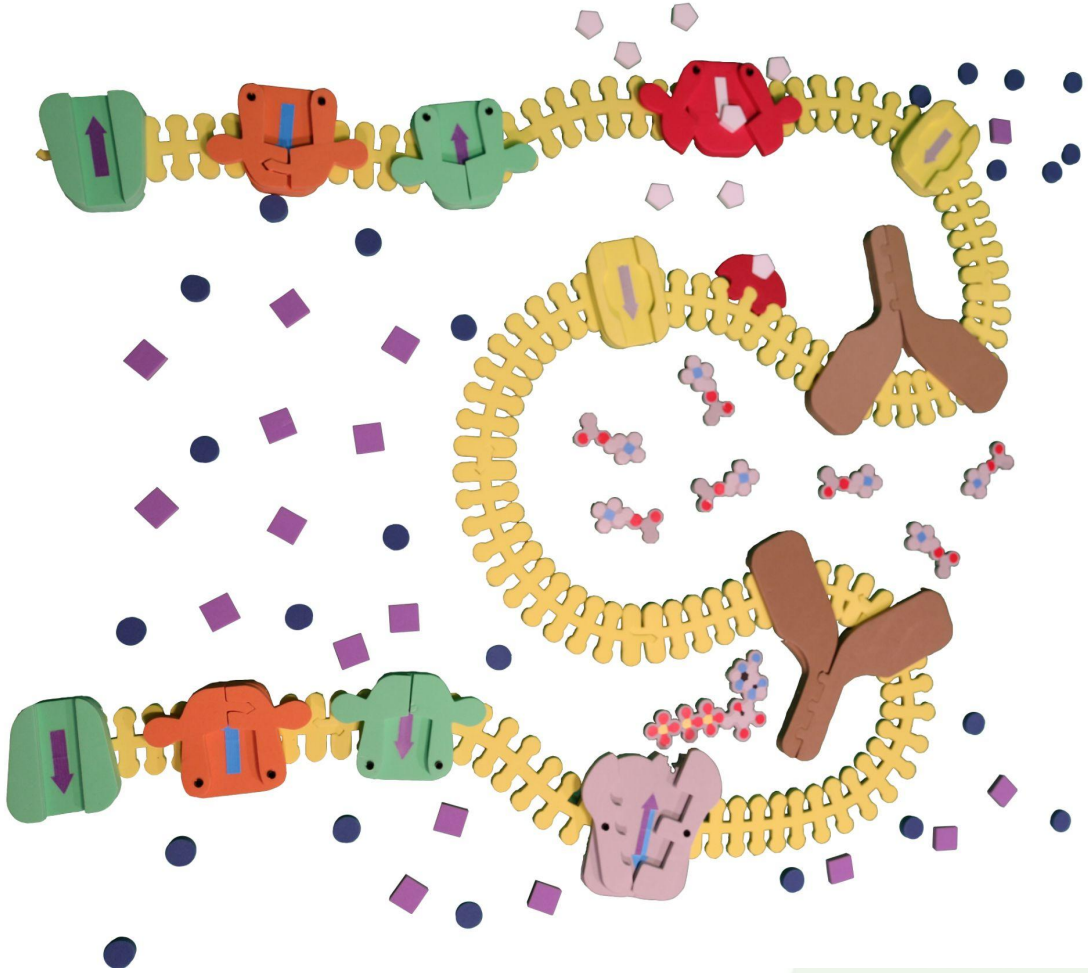
Neuron structure with the **Neuron Modeling Kit**

Synapse Kit Introduction

3D Molecular Design's **Synapse Construction Kit**

Allows modeling of:

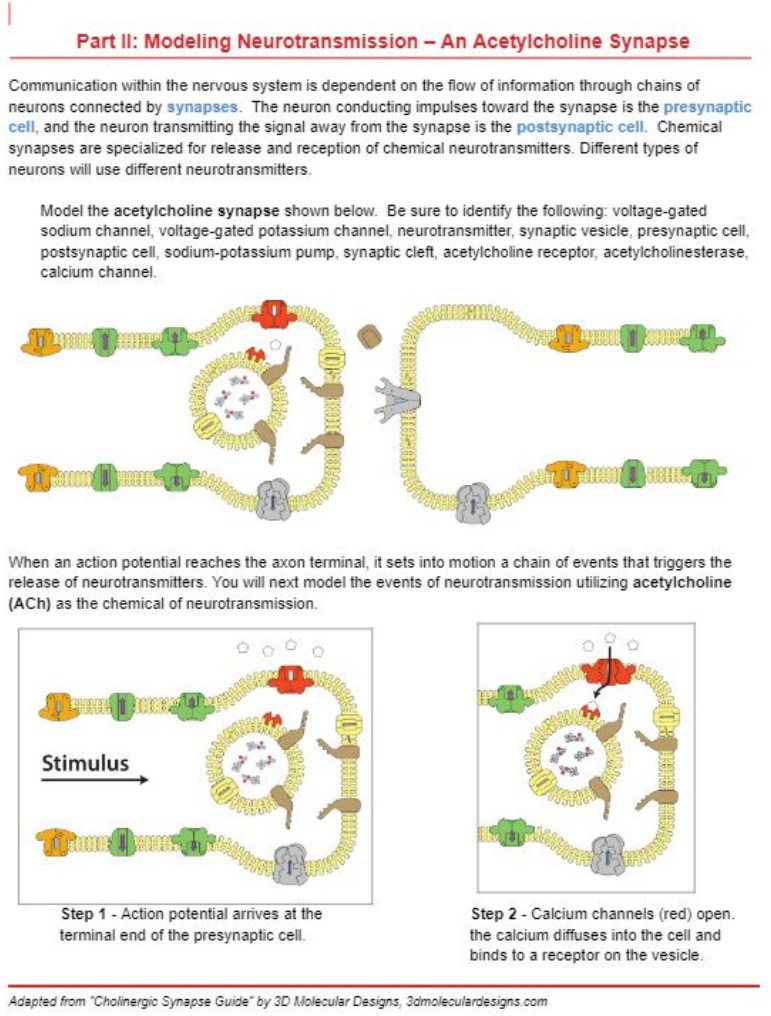
- action potential
- acetylcholine synapse
- GABA synapse
- dopamine synapse



Synapse Kit Introduction

Follow the student handout to model synaptic transmission at an acetylcholine synapse: Steps 1-6.

Link to handout



Part II: Modeling Neurotransmission – An Acetylcholine Synapse

Communication within the nervous system is dependent on the flow of information through chains of neurons connected by **synapses**. The neuron conducting impulses toward the synapse is the **presynaptic cell**, and the neuron transmitting the signal away from the synapse is the **postsynaptic cell**. Chemical synapses are specialized for release and reception of chemical neurotransmitters. Different types of neurons will use different neurotransmitters.

Model the **acetylcholine synapse** shown below. Be sure to identify the following: voltage-gated sodium channel, voltage-gated potassium channel, neurotransmitter, synaptic vesicle, presynaptic cell, postsynaptic cell, sodium-potassium pump, synaptic cleft, acetylcholine receptor, acetylcholinesterase, calcium channel.

When an action potential reaches the axon terminal, it sets into motion a chain of events that triggers the release of neurotransmitters. You will next model the events of neurotransmission utilizing **acetylcholine (ACh)** as the chemical of neurotransmission.

Stimulus

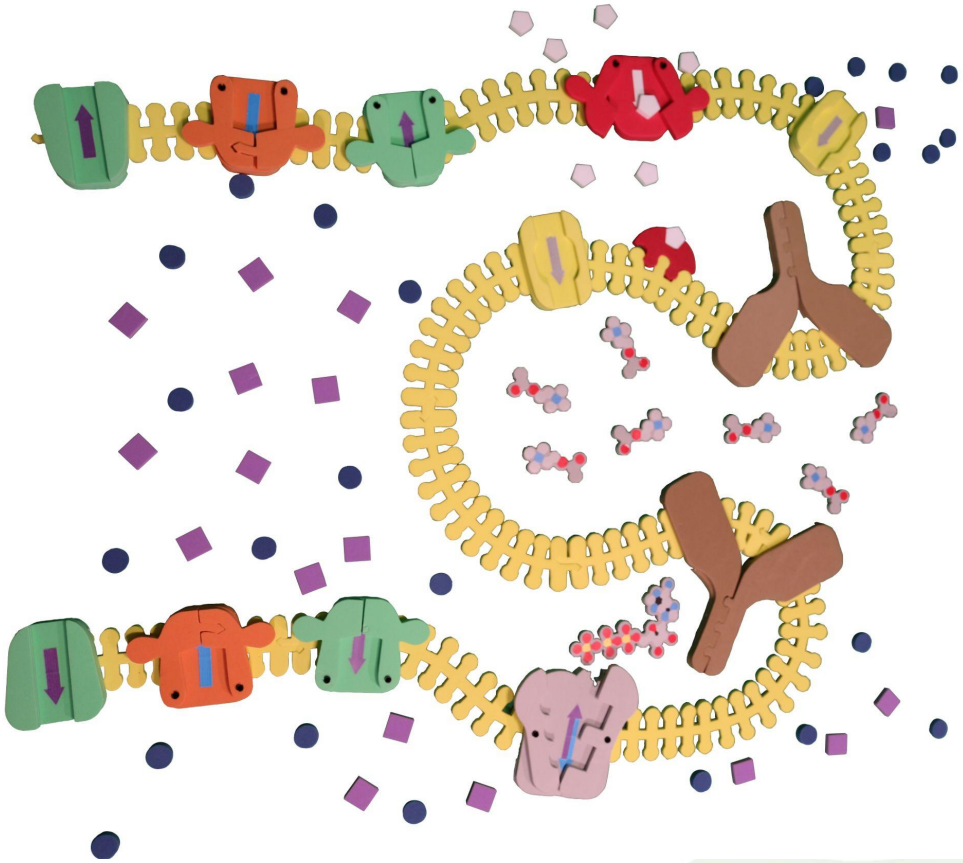
Step 1 - Action potential arrives at the terminal end of the presynaptic cell.

Step 2 - Calcium channels (red) open. the calcium diffuses into the cell and binds to a receptor on the vesicle.

Adapted from "Cholinergic Synapse Guide" by 3D Molecular Designs, 3dmoleculardesigns.com

Implementation ideas

- Follow my lead
- Show me
- Model, then write
- Stop motion animation as assessment

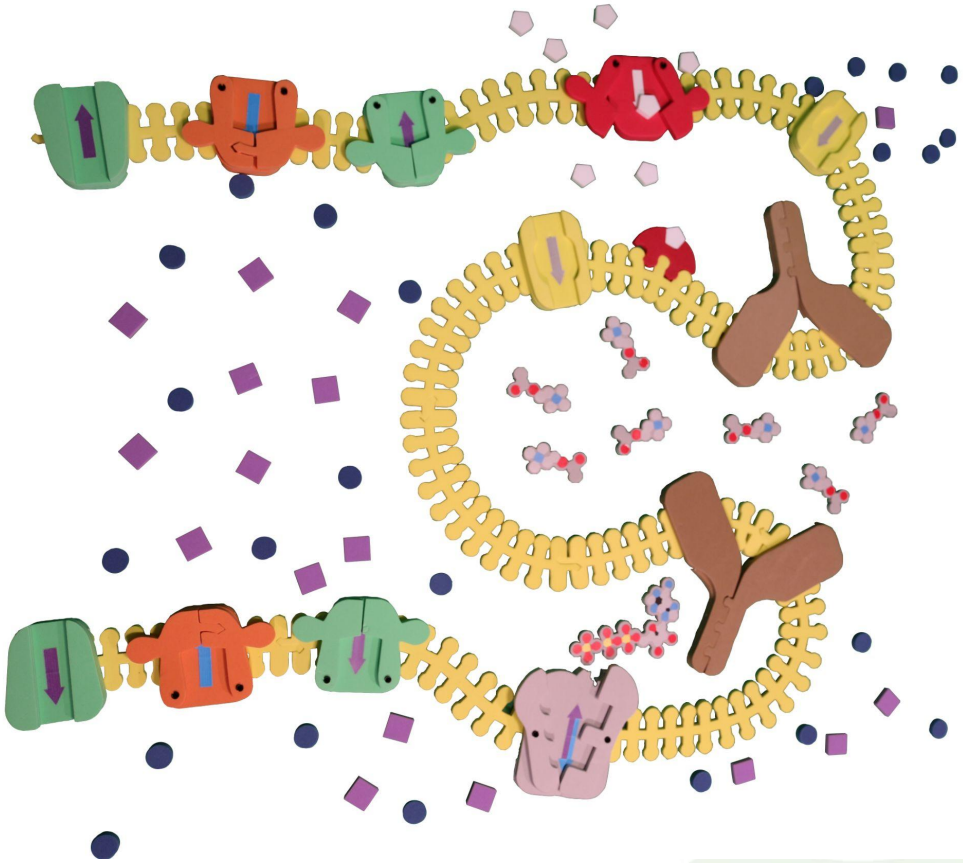


Teaching Synaptic Transmission

Reflections on the kit so far?

How could it be useful in your context?

What questions do you have so far?



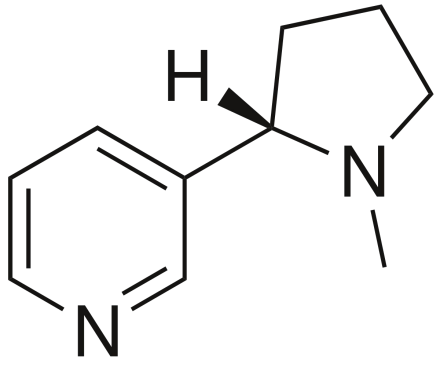
Addiction

Basic biological principles that can be taught using models:

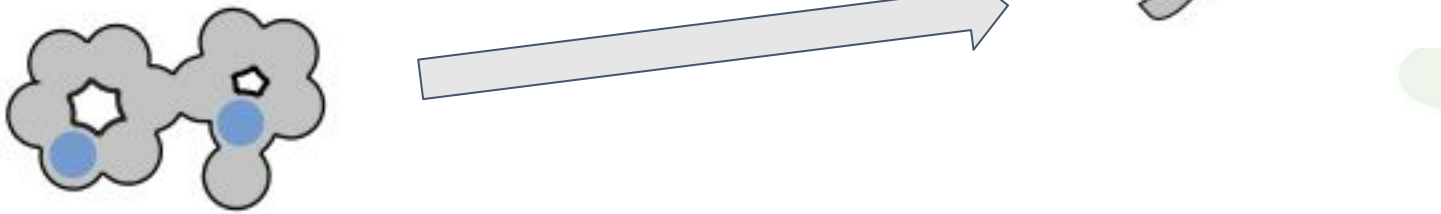
- Drugs manipulate natural pathways in the brain
- Effect may amplify (stimulant) or slow (depressant) chemical communication in the brain
- Most psychoactive drugs are linked to dopamine secretion (generates the high)
- Down-regulation explains drug tolerance

Example #1: Nicotine

- Binds irreversibly to the acetylcholine receptor (agonist)
- Over-stimulates the pathway

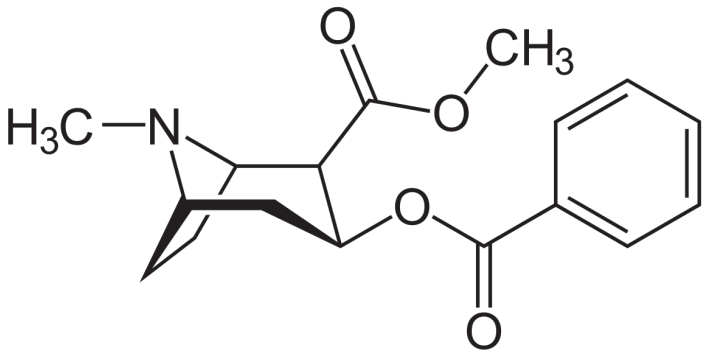


Nicotine

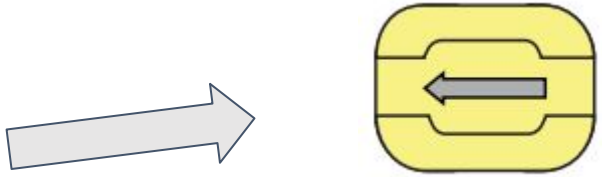


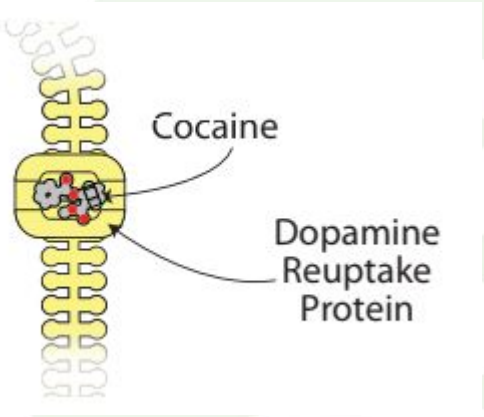
Example #2: Cocaine

- Binds to dopamine reuptake transporters
- Dopamine persists in the synapse, continuing to stimulate



Cocaine

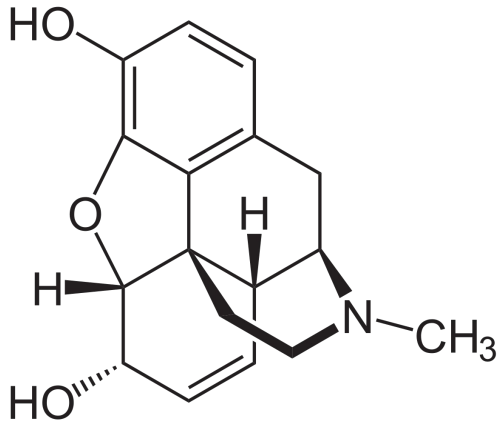




Example #3 - Opioids

- Naturally-occurring chemical messengers (endorphins)
- Act as powerful analgesics (pain killers)
- Opioids can be found elsewhere in nature (morphine)
- Synthetic opioids (Fentanyl) bind stronger to receptors

Morphine (right) can be extracted from the poppy plant (left)

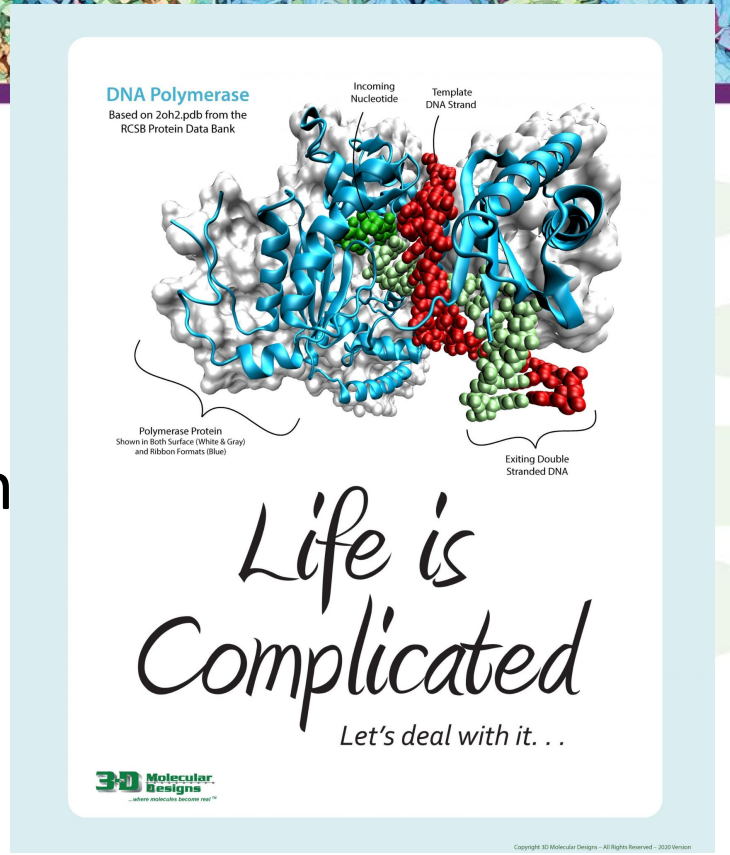


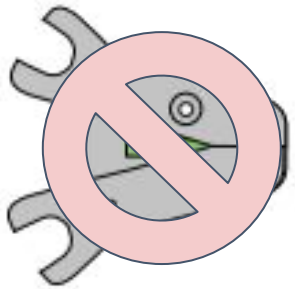
References: Untangling the complexity of opioid receptor function, Physiology of opioid receptor

Opioid addiction

One simplification:

Opioids inhibit GABA receptors in the reward center of th brain, leading to increased dopamine release





GABA Receptor

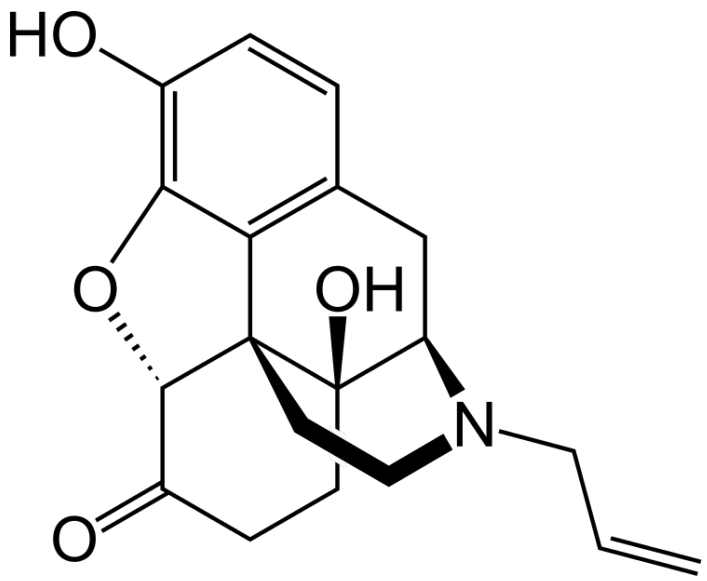
- An ionotropic ligand-gated receptor located in the postsynaptic cell membrane
- Activation occurs by the binding of two GABA molecules resulting in a selective influx of Cl^- into the postsynaptic cell leading to hyperpolarization

References: Untangling the complexity of opioid receptor function, Physiology of opioid receptor

Opioid treatment

Naloxone (Narcan):

Antagonist of the opioid receptors; blocks the binding sites for opioids

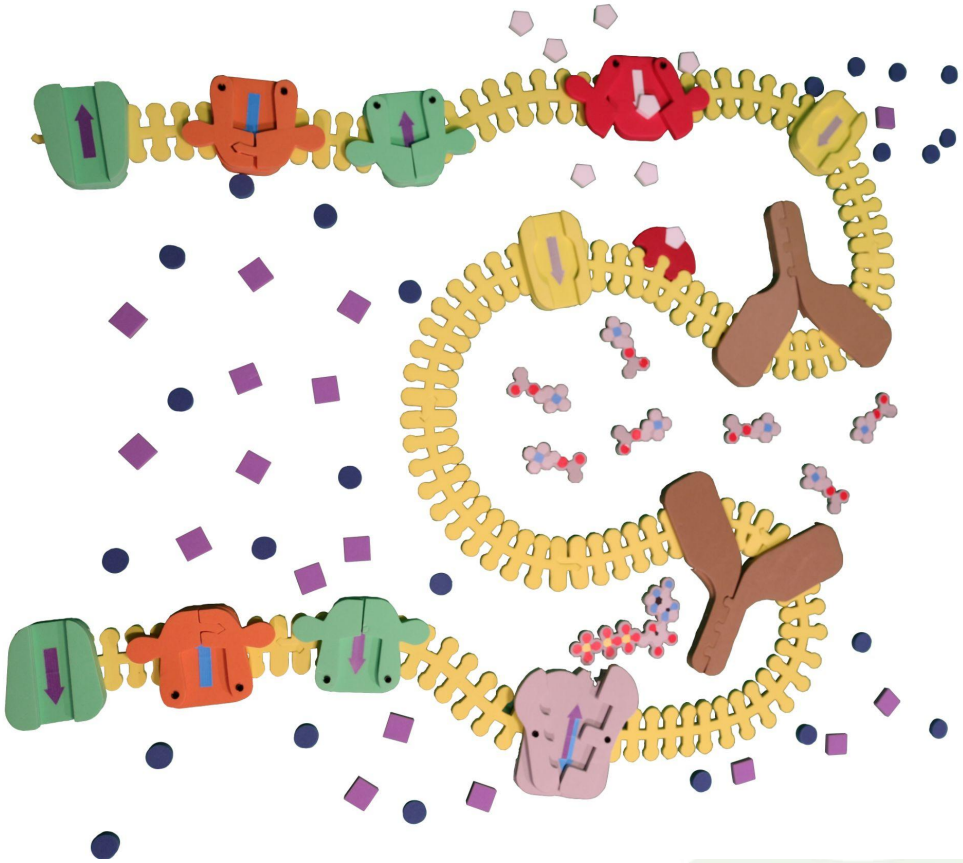


References: [Naloxone drug facts]

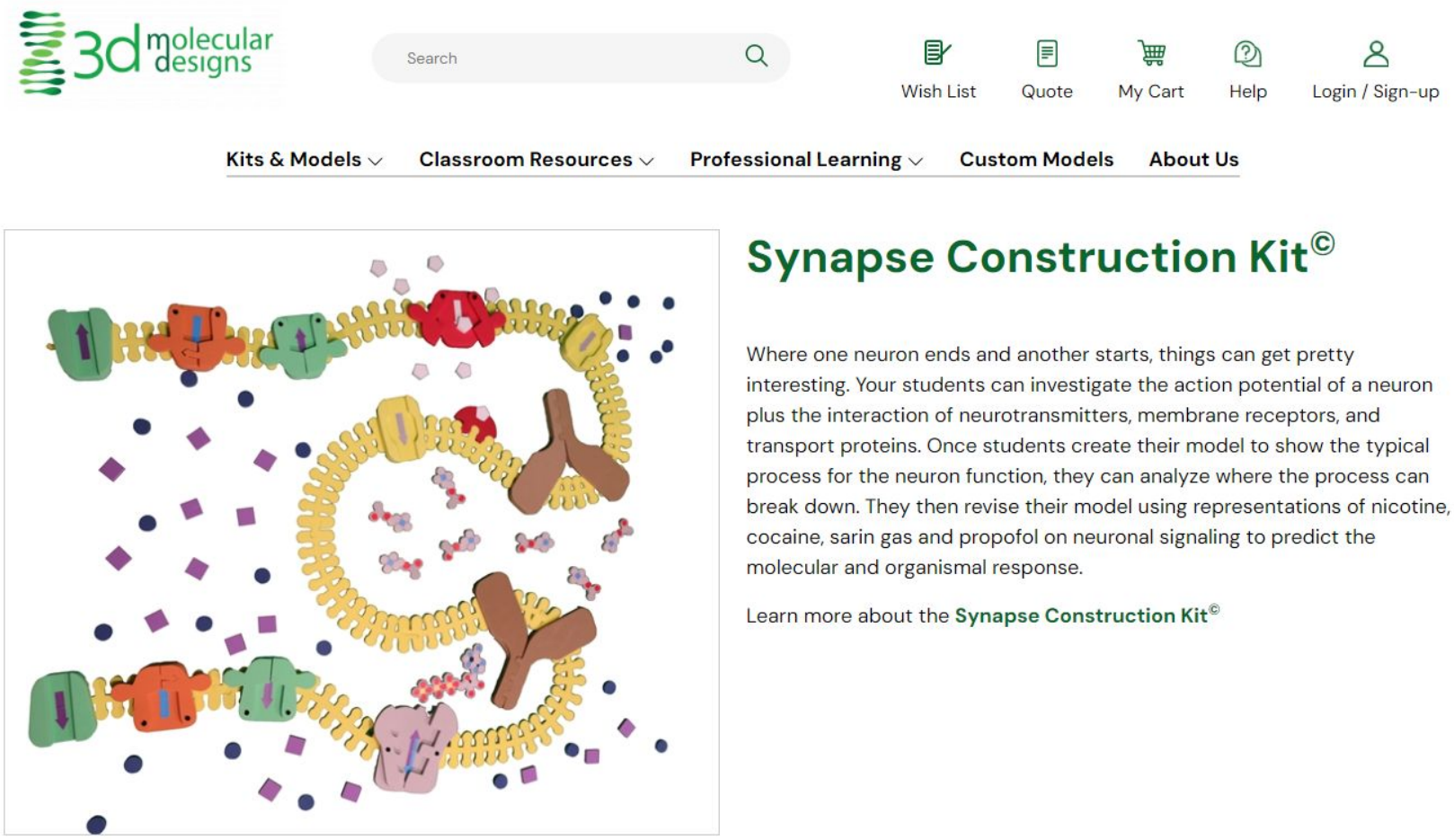
Implementation ideas

Scale appropriately!

- Demo and discuss
- Jigsaw - students prepare different drug mechanisms
- Research - choose drug and develop your own model



20+ resources for this kit are available on the 3d Molecular Designs website.



https://3dmoleculardesigns.com/classroom_resources/synapse-construction-kit/

3d molecular designs
Transforming Science Learning

Uncovering the Truth: Modeling a DNA Replication Error

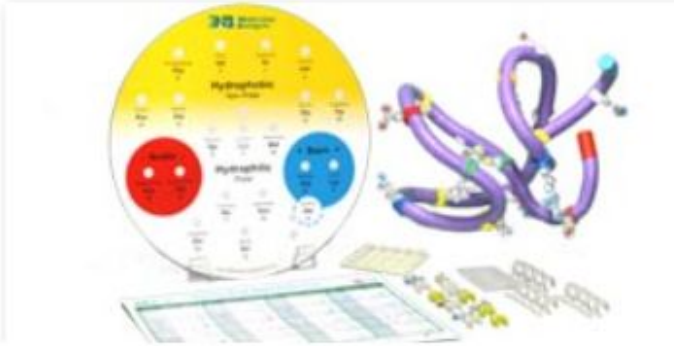
Sherry Annee
2:00-3:15

Modeling Kits

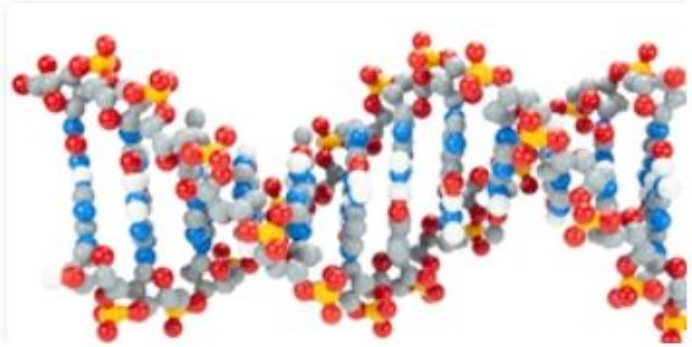
3D Molecular Designs has a variety of modeling kits suitable for teaching a wide range of topics.

See their website to view their catalog.

Water Kit



Amino Acid Starter Kit



Dynamic DNA Kit

Cellular Landscapes

Professional Development Opportunities

Multi-day summer courses offered in-person in Milwaukee, WI.

July 29-Aug 2

Aug 5-9

Modeling the Molecular World

See the 3D Molecular Designs website for further information!

https://www.3dmoleculardesigns.com/

Time to raffle!!

THANK YOU FOR ATTENDING!

Kits and models used in this session:

Synapse Construction Kit (SCK-01)

Neuromuscular Synapse Poster (DGSP)

Purchase kits at **3dmoleculardesigns.com**.

Scan this QR code to fill out a survey for a 20% coupon code off most kits and a chance to win a $50 gift card!

Workshop NGSS Connections

SEPs	CCCs	DCIs
1. Asking questions and defining problems	1. Patterns	**LS1: From Molecules to Organisms: Structures and Processes**
2. Developing and using models	2. Cause and effect: Mechanism and explanation	LS1.A: Structure and Function
6. Constructing explanations and designing solutions	4. Systems and system models	LS1.D: Information Processing
	6. Structure and function	
	7. Stability and change	

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