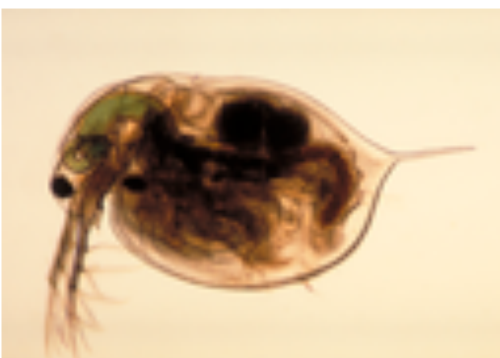
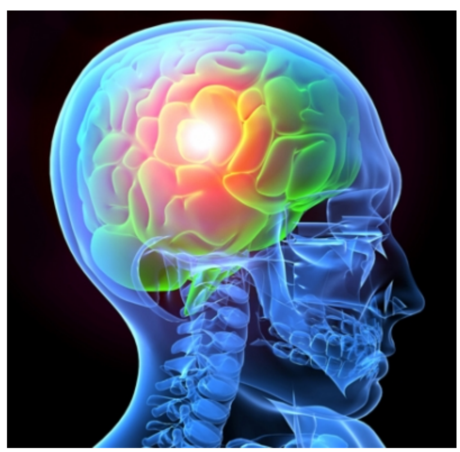
UNIVERSITY OF NEW ENGLAND

Center for Excellence in the Neurosciences

Drugs and Addiction

High School





Module Components:

- Types of drugs and their effects
- Neural pathways of addiction demonstration
- Effects of drugs daphnia demonstration

For more information on specific drugs, drug abuse, addiction or other resources, please visit the National Institute of Drug Abuse website (drugabuse.gov).

Classifications of drugs of abuse

Drugs are typically classified into categories based on their effects on the central nervous system. This includes illegal drugs, legal - prescription drugs, and legal drugs such as alcohol.

3-5 categories:

CNS Stimulants: Stimulants are drugs that raise energy and alertness.

- Neurobiology: Stimulants raise levels of excitatory neurotransmitters like dopamine or norepinephrine in the brain.
- Examples: caffeine, cocaine, methamphetamine, ecstasy, bath salts, prescription ADHD medications like Adderall and Ritalin.
- Effects: elevated body temperature, heart rate and blood pressure; increased alertness; increased joy, pleasure and talkativeness; feelings of anxiety or irritability.

CNS Depressants: Depressants are drugs that slow brain activity.

- Neurobiology: Depressants slow activity in the brain and CNS by raising levels of inhibitory neurotransmitters (ex. GABA agonists).
- Examples: Alcohol, anti-anxiety medication such as Xanax and Valium, sleep medication such as Ambien or Lunesta, many inhalants.
- Effects: feelings of relaxation, calming, slowed reflexes, lack of coordination, sleepiness, impaired concentration.

- When taken in combination with other CNS depressants or opioids, they can cause severe respiratory problems (slowed and stopped breathing).

Opioids: Some people put with depressants

- Opioids are drugs that have pain-relieving properties and can produce feelings of pleasure or euphoria
- Examples of opioids: morphine, heroin, oxycodone, codeine
- Neurobiology: Opioid drugs act on receptors known as opioid receptors.
- Opioids have many similar effects as CNS depressants and can be extremely dangerous if used at the same time as depressants.

Hallucinogens/Psychedelics: Hallucinogens or psychedelics are drugs that alter perception and cause hallucinations.

- Neurobiology: Hallucinogens act on excitatory neurotransmitters such as serotonin (LSD, MDMA/ecstasy) and glutamate (PCP).
- Examples: LSD, PCP, psilocybin (mushrooms), ecstasy and THC (in high doses)
- Effects: hallucinations, difficulty concentrating and communicating, inability to differentiate between hallucinations and reality. Some people become agitated, anxious or aggressive, while others become passive and sedated.

Cannabinoids are sometimes placed into their own category.

Some drugs fit into more than one category. Marijuana (THC) can act like a CNS depressant at low doses and a hallucinogen in higher doses. Similarly, ecstasy (MDMA) and bath salts are stimulants that can cause hallucinations.

Neurobiology of Drugs and Addiction

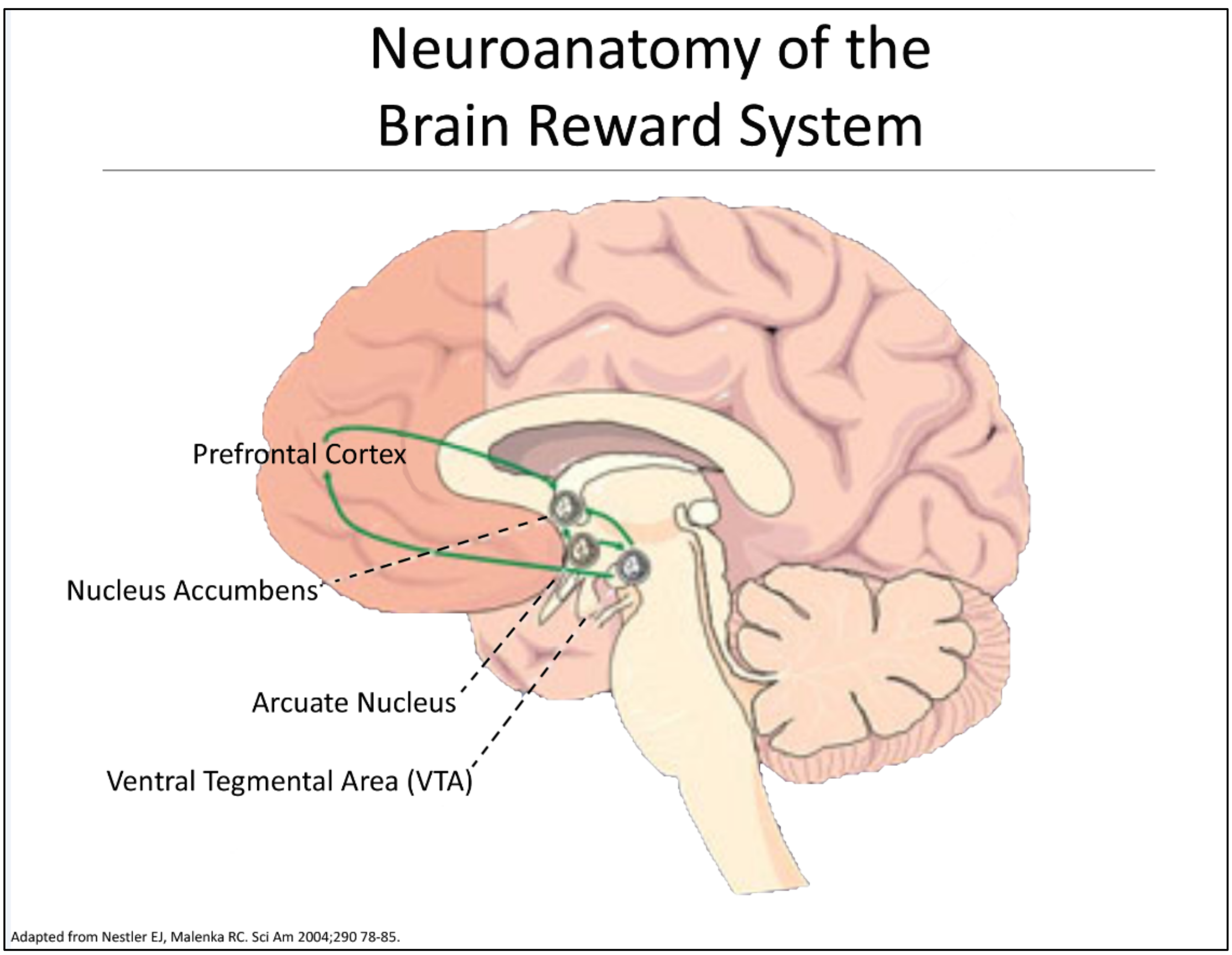
Exploring addiction pathways in the brain

This demonstration shows one of the primary addiction pathways in the brain and how it is activated by normal behaviors and by drug addiction.

Supplies:

- Brain reward pathway poster
- Electric gun with power strip connector

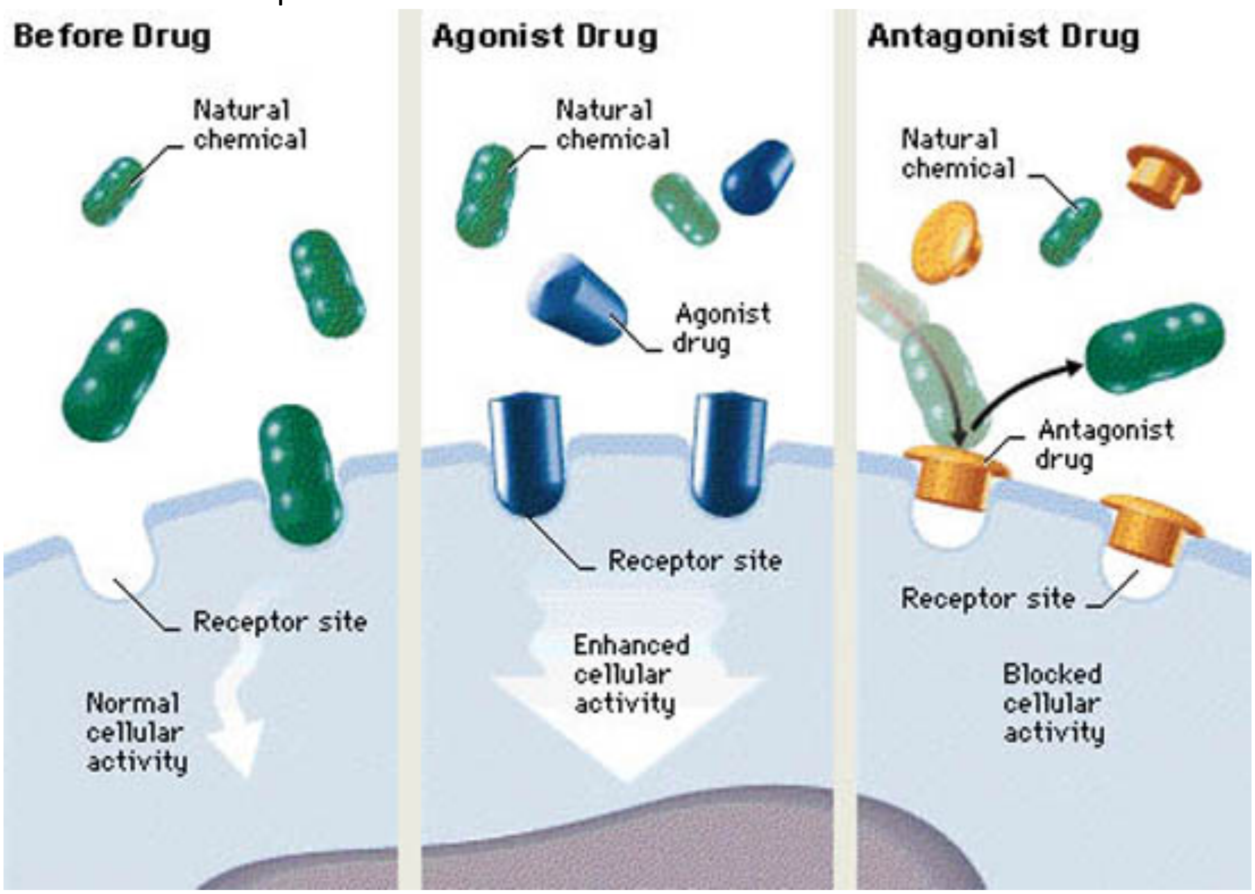
Many parts of the brain are involved in drug use and addiction. This demonstration focuses on 1 such pathway, commonly known as the reward pathway.



Introduce the concept that drugs of abuse work on endogenous neurotransmitter systems. Our brain has a variety of chemicals, called neurotransmitters, that active or inhibit our brain cells (called neurons). Different parts of the brain use different neurotransmitters, creating circuits that have different functions.

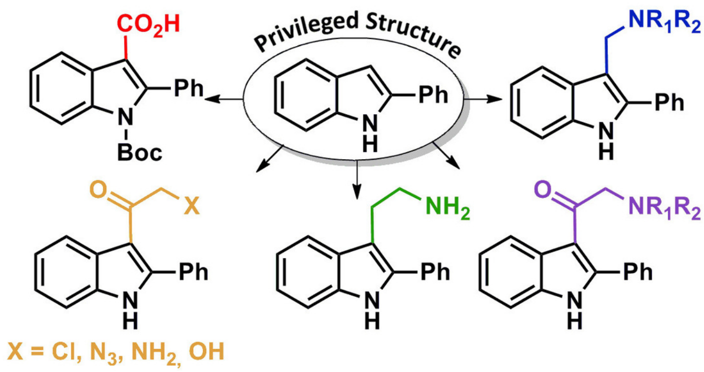
Drugs activate the pathway by mimicking neurotransmitters. This is called being an "agonist". Other drugs may inhibit the neurotransmitter. This is called being an antagonist.

Show and discuss picture.



The way that drugs can do this is that they share some critical structural features with the neurotransmitter that makes them able to bind to the same receptor. However, the changes made to the molecule can affect the function, making them affect the receptor more strongly (agonist), not at all (antagonist) and just differently.

Show and discuss picture.



Example: The reward pathway

The reward pathway goes from the ventral tegmental area (VTA) to the nucleus accumbens (NA), which is known as the pleasure center of the brain. The NA passes information along to the prefrontal cortex. This pathway is activated by a variety of pleasurable stimuli, like food, rewards or drugs of abuse.

1. With the gun connected to the power strip, wind the motor slowly so that the lights flicker on and off or stay on at a low rate.
    a. This demonstrates activation of the reward pathway due to normal activities. For example, getting something back with a good grade or doing something fun with a friend could activate this pathway.
2. Now wind the motor as quickly as possible so that the lights come on brightly.
    a. This demonstrates how the reward pathway is activated due to drugs. For example, cocaine floods the reward pathway with an excess of dopamine. Dopamine (an excitatory neurotransmitter) causes neurons in this pathway to fire rapidly, causing feelings of euphoria.
3. As your arm gets tired from winding the motor, let the lights go out.
    a. This demonstrates the depletion of dopamine after the drug use. The neurotransmitters which were rapidly used up by the drug are no longer available to activate the neural pathway, leading to the low feelings and "crash" that can follow drug use.
4. Normal activities do not activate the reward pathway to the same degree that drug use does. Some people can become addicted due trying to replace the euphoric feeling from their first drug use.

5. Addiction is when a person (or animal) engages in a compulsive behavior to get some reward or stimulation, even when faced with negative consequences. The reward pathway is involved in both cravings for a drug and the reward associated with the drug. Disruption in communication between the reward pathway (specifically the prefrontal cortex) and other parts of the brain contributes to compulsive drug use.

Effects of Drugs on an Animal Model

Examining the behavioral changes caused by drugs

This demonstration allows students to clearly observe the effects of drugs on behavior in a live organism.

Materials:

1. Daphnia in broth
2. (3) Pipettes - 1 pipette cut at ~45 degree angle
3. Vaseline
4. Microscope slides
5. Rubber rings (O-rings; 1 for each daphnia to be observed)
6. Ringer's solution
7. 1/10 dilution of depressant (e.g. ethyl alcohol)
8. 1/10 dilution of stimulant (e.g. adrenalin chloride)
9. Student microscope
10. Paper and markers
11. Clock/stopwatch

Procedure:

A) Safety:

Take care handling any chemicals that might affect the heart rate of Daphnia. Observe normal, good laboratory hygiene practices when completing the practical.

B) Preparation:

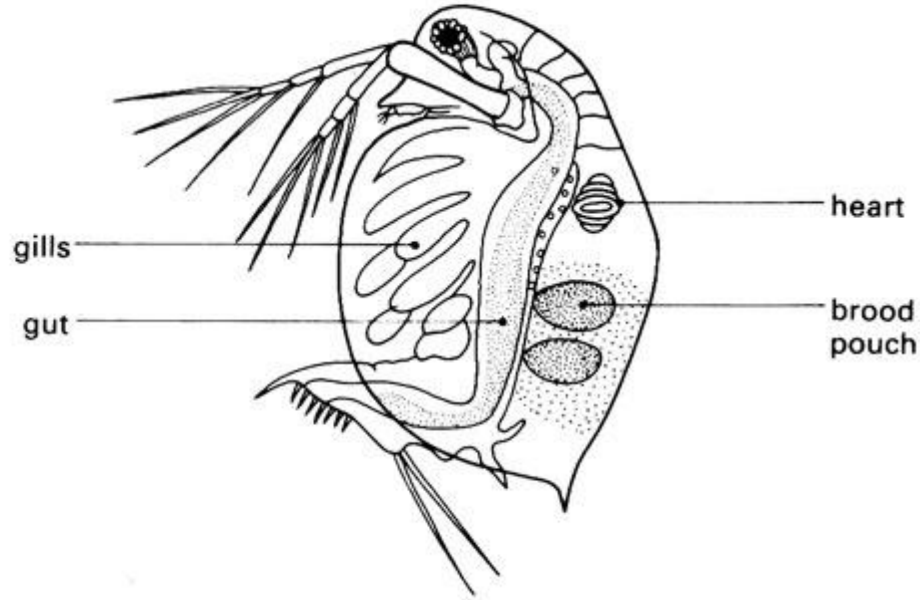
1. Dilutions: It may be helpful to make the dilutions before the experiment begins in order to save time.

-Prepare with 34 drops of ringers solution and 4 drops of the full strength alcohol/adrenalin

2. Slide Preparation:
   - -Coat the outside of the O-ring with Vaseline
   - -Press the Vaseline side down onto the slide and remove again to get an indication of where the ring will eventually be placed
   - -Spread a thin layer of Vaseline to fill in the circle. Dab once with a wipe to make sure the layer is very thin
   - -Replace the O-ring and add a few drops of Ringer's solution to make a "pool"

3. Daphnia Selection:
   - -Search for the largest, most red/orange daphnia you can find. Do not select very small daphnia, their internal structures are difficult to see

4. Adding the Daphnia:
   - -Use the cut pipet to remove one Daphnia from its holding container
   - -Before dropping the Daphnia in the ringers, try to get it to the edge of the pipet to minimize the amount of liquid in the pool
   - -Drop by drop remove liquid until the Daphnia is one or two drops away
   - -At this point, the Daphnia should have enough liquid to be covered but not enough that it can swim excessively around. You can remove excess liquid with a pipet
   - -Observe the Daphnia under the microscope, and firstly make sure you can either see a heart (look behind the eye) or at least a flutter in that area. Another Daphnia may need to be selected if this structure cannot be seen.
   - -It may not always be possible to accurately count the heartbeats because of the speed or inability to view the heart. If possible count the number of beats per minute using three 20-second intervals and record as the control in the results table. In order to efficiently count heartbeats, provide the student with a piece of blank paper and a marker. As the student looks at the Daphnia, make one dot on the paper (without the student moving his/her gaze from the daphnia). After the time interval has concluded, count the number of dots on the paper. If that is not possible, you can observe speed of the heart without counting and compare it to later speeds, or focus on the leg movement. If time is limited conduct only one trial of 15-seconds and multiply the number of dots on the paper (representing heartbeats observed) by 4 in order to obtain the heart rate per minute.



C) Investigating the effect of CNS stimulants: ***(Alternate protocol for drug investigation in section E)***

1. Using a pipette, add one drop of the diluted *CNS stimulant chemical (adrenalin)* to the ring containing the Daphnia.

2. If possible, count and record the beats per minute of the Daphnia's heart using three 20-second intervals, as done with the control. If beats cannot be counted observe the speed and movements of the Daphnia and record results in observations.

3. If beats are recorded, average the three trials and record in your table.

D) Investigating the effect of CNS depressants: ***(Alternate protocol for drug investigation in section E)***

1. Using a pipette, add one drop of the diluted *CNS depressant chemical (ethyl alcohol)* to the ring containing the Daphnia.

2. If possible, count and record the beats per minute of the Daphnia's heart using three 20-second intervals, as done with the control. If beats cannot be counted observe the speed and movements of the Daphnia and record results in observations.

3. If beats are recorded, average the three trials and record in your table.

E) Investigating the effects of CNS mystery drugs:

1. Using a pipette, add one drop of the diluted *Mystery Drug A* or *Mystery Drug B* to the ring containing the Daphnia. Each mystery drug should already be diluted in vials marked "Drug A" or "Drug B." Typically, one mystery drug is a stimulant and the other is a depressant.

2. If possible, count and record the beats per minute of the Daphnia's heart using three 20-second intervals, as done with the control. If beats cannot be counted observe the speed and movements of the Daphnia and record results in observations.

3. If beats are recorded, average the three trials and record in your table.

4. Based on recorded heart rate data and observations of organism behavior, determine the class of each mystery drug (presenter should know which mystery drug is a stimulant and which is a depressant).

5. Use remaining time to discuss the results of the experiment and other possible outcomes (e.g. What if we used a higher dose of stimulant/depressant?)

Results

Treatment	Beats per 20 Second Intervals	Beats per Minute	Average Beats per Minute	Observations
Control:	Trial 1:_____ x 3 = Trial 2:_____ x 3 = Trial 3:_____ x 3 =	Trial 1: _________ Trial 2: _________ Trial 3: _________		
Stimulant: _______________	Trial 1:_____ x 3 = Trial 2:_____ x 3 = Trial 3:_____ x 3 =	Trial 1: _________ Trial 2: _________ Trial 3: _________		
CNS Depressant: _______________	Trial 1:_____ x 3 = Trial 2:_____ x 3 = Trial 3:_____ x 3 =	Trial 1: _________ Trial 2: _________ Trial 3: _________		