**LESSON PLAN NAME**

**Topic: Drugs and the Brain**

**Developed by:**

**Grades:** 9th-12th grade

**Vocabulary words:** neuron, synapse, neurotransmitter, basal ganglia, excitatory, inhibitory, agonist, antagonist

**Materials:** Powerpoint slide

**Time needed: 40 minutes**

Introduction (5-10 minutes): Explain what the brain does normally. Teach the concept of synapses and neurotransmitters

Slides (35 minutes): Different drugs that target on the brain, different regions of the brain that drugs act on, how drugs change the synaptic connections

**Summary:** Students learn about different drugs that act on the brain and how they act on

**Prerequisites for Students:** None. Helpful if students understand the concept of cells.

**Learning Goals:**

* Learn two different types of synapses and corresponding neurotransmitters
* Learn how two neurons communicate to one another through a synapse
* Learn how different drugs target different brain regions and act on synaptic transmissions by either activating or inhibiting receptors

**Background for instructor:**

* Refresh basic knowledge about neurons and synapse
* Excitatory synapses use NMDA and AMPA as neurotransmitters and inhibitory synapses use GABA.
* Basal ganglia pathway has been studied to see how drugs can modulate the dopamine signal, thus enhancing or inhibiting the brain reward circuitry.
* Refresh basic knowledge of how fMRI works: it measures vascular (BOLD) signals as proxy for brain activation.
* Be ready to run the auditory oddball task and Stroop task to students.

**Set-up:** Setup a projector and computer for the slides

**Lesson Outline:** Introduce yourselves and start by asking the students how they feel different after having Red Bull. Ask the students to name drugs that might target the brain. What are some physical, psychological effects of these drugs? How would you categorize them?

A: Stimulants, Depressants, and Hallucinogens. Some drugs fall into multiple categories –e.g. marijuana.

 Before talking about how our brains look like under drugs, talk about how brain work normally. Your brain takes information in through your surroundings, process it, and you respond to it. So your response can be an action, a thought, a mood, a behavior, a perception, or learning. For example, my senses tell me I’m cold when I walk outside. My brain helps me take that information and I decide to act: I’m going to go back inside to get a coat. The brain can be divided into different parts and those parts have different jobs that they are mostly responsible for. These parts work both separately and together to form the output of the brain. Average adult male brain contains over 86 billion neurons. Neurons connect with and transmit information through connections called synapses. An electric signal will travel down the cell until it gets to the next cell where it has a connection. That connection is called a synapse.

 When the electrical signal reaches the synapse of the signal sending cell it signals the cell to release factors into the space between the cells. These factors are called “neurotransmitters”. Neurotransmitters bind to receptors on the signal receiving cell and the electrical current travels to the receiving cell. When the signal sending cell is no longer stimulated, the neurotransmitters are cleared from the synapse or taken back up to be recycled for next time.

 There are two types of synapses: excitatory and inhibitory. Excitatory synapse is a synapse in which an action potential in a presynaptic neuron increases the probability of an action potential occurring in a postsynaptic cell. Inhibitory synapse, on the other hand, is a synapse in which the more presynaptic cell is activated, the less the postsynaptic cell is.

 In this session, we will cover caffeine, alcohol, and marijuana. Different drugs target different brain regions, neural pathways, neuronal types, and neurotransmitter receptors. All of these variables take action together generate variabilities in behavior.

 Caffeine is a stimulant. After you have RedBull, you feel enhanced alertness and wakefulness, endurance, productivity and motivation, increased arousal and locomotion. Also your perception of hunger and fatigue decreases. It has been shown that the activity in the pituitary gland increases after caffeine intake. Functional MRI during an auditory odd ball task shows that the motor task related activity increases with caffeine intake.

 Alcohol is a kind of depressants. Some of the behavioral changes includes anxiety reduction, pain relief, sedation, cognitive/memory impairment, euphoria, dissociation, and physiological changes. Alcohol acts as an agonist at inhibitory synapses and antagonist at excitatory synapses. Alcohol stimulates the release of beta-endorphins that bind to opioid receptors, thereby releasing dopamine. Dopamine release is associated with the pleasurable, reinforcing and rewarding effects of alcohol. Stroop Test: can be a measure of cognitive flexibility. Adolescents with family history of alcohol use show increased activation in the frontal lobe during the Stroop test.

 Marijuana is both a depressant and stimulant. Behavioral effect varies, including relaxation, stimulation, hallucinations, and paranoia. We have endogenous cannabinoid receptors to which marijuana bind to and activate. Some of the side effects of cannabinoid receptor activation include increased lipogenesis, increased insulin resistance, and decreased satiety. Compared to non-smokers, marijuana smokers demonstrated significantly lower anterior cingulate activity during Stroop task.

**Wrap-up, final thoughts**: While the topic is on drugs and the brain, it is important to cover the fundamental of how synapses work.