Instructions
Only use the mouse to move through the program!

Make sure to answer all questions as you go. Slides with corresponding questions in the workbook are indicated by the symbol.

Follow the slides through by clicking on the next slide symbol in the bottom right hand corner.

If you want to replay a slide click on the play again symbol in the bottom right hand corner.

When completing the interactive drug section you can move back to choose a drug and also to see how drugs act by clicking on their links in the bottom right hand corner.

SOME BASIC NEUROSCIENCE
Neurons have specialised extensions
1: Label the parts of a neuron by selecting the correct term from the box below.

Cell body, axon, dendrite, synapse
2: Complete the following by filling in the blank spaces.

Nerve pathways are our information super highways. They are made up of cells called Neurons _. Both electrical and chemical signals are used to transmit information along a nerve pathway.

Signal Transmission

3: Write the appropriate signal received and transmitted by the three neurons in boxes below.

<table>
<thead>
<tr>
<th>Neuron 1</th>
<th>Neuron 2</th>
<th>Neuron 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEMICAL</td>
<td>CHEMICAL</td>
<td>CHEMICAL</td>
</tr>
</tbody>
</table>

Using an arrow indicate which direction the signal is travelling in from one neuron to another.

The synapse in close-up

4: Molecules called neurotransmitters carry the message across the synapse and bind to receptor molecules on the next post-synaptic neuron. Draw a line to show the path taken by a neurotransmitter across the synapse.
**Chemical signals and receptors**

Just like a key needs to be a certain shape to fit a lock, the shape of the signalling molecule determines whether it can bind to its specific receptor.

5: Circle one of the following molecules to show which molecule you think will bind to the receptor below?

![Molecules and receptor diagram](image)

Congratulations! You have now acquired the basic knowledge to understand how drugs act on neurons. Now that you have worked through the introduction it is time to take a look at how drugs act on neurons.

Drugs are molecules just like neurotransmitters and have a specific shape. If their shape is similar to that of a neurotransmitter they will bind to the receptor just like a key fitting into a lock.
Drug action on neurons

Click on each of the 3 links to see how various drugs can act on neurons and answer the questions. Make sure to try them all.

Mimicking neurotransmitters

Drugs mimic neurotransmitters because they have a similar shape. These drugs are able to bind to the postsynaptic receptors in the same way that the brain's normal chemical messengers, the neurotransmitters, can.

Pre-synaptic neuron NOT activated.
Neurotransmitters still stored in the end of axon.

Drug binds to receptors on the post-synaptic neuron and activates the neuron.

Electrical impulse

Drugs the same shape as the neurotransmitter can mimic the neurotransmitters.

6: Circle which of the following drugs in the interactive choice is going to be able to mimic the neurotransmitter and activate the post-synaptic neuron?

Nicotine
Alcohol

Explain your choice:

__________________________________________________________________________

__________________________________________________________________________
Blocking postsynaptic receptors

Some drugs affect neurons by blocking the receptors that neurotransmitters normally act on.

1. Receptors are blocked by drug

2. Pre-synaptic neuron-electrical signal causes release of neurotransmitters

3. Neurotransmitters-cross synapse and try to bind to receptors- CANT!

4. NO electrical signal in Post-synaptic neuron

7: Circle which of the following drugs in the interactive choice is going to be able to block the postsynaptic receptor?

- LSD
- Antipsychotics
- Scopolamine

Explain your choice:
__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
Blocking reuptake of neurotransmitters by the pre-synaptic neuron

Normal reuptake of neurotransmitters

Once a neuron has sent the message on to the next neuron it doesn’t want to keep sending the same message. It would be like sending the same text message to your friend over and over again. To stop sending the message after a neurotransmitter has done its job it is taken back up into the neuron it came from to be stored. In this way the neuron is recycling its chemical messengers (the neurotransmitters).

Drugs can block reuptake of neurotransmitters

Some drugs can block the reuptake of neurotransmitters. This means that the neurotransmitters can remain in the synapse where they will continue to stimulate postsynaptic receptors and continue to activate the postsynaptic neuron. This would be like sending a text message over and over again.

8: Circle which of the following drugs in the interactive choice is going to be able block the reuptake channel in the choice scenario? (HINT: Be careful to check the shape of the binding site on the re-uptake channel on the computer screen).

▲ Marijuana   + LSD   ◆ Cocaine
The problem with drugs

Drugs alter how we think feel and act. Many drugs impair our judgement and increase the likelihood that we will do dangerous things. They can also make us do stupid things. Whilst they can sometimes make as feel good to start off with, this is short lasting and they generally end up making us feel really bad. In the long term they can also cause serious and often permanent damage to our brains. This is because the way drugs act on neurons ends up changing how the neurons work and can kill the neurons.

9. Looking at the consequences of drug use on the brain

9a: Do all drugs act on the same neurotransmitters? Circle the correct answer Yes / No
9b: What are the long term effects of all drugs on neurons?

Ans: Decreases neuron activity, neuron DEATH

Click on the scan links –to take a look at some brain scans showing how different psychoactive drugs affect brain activity and answer the questions for each drug on the following pages.
ETHANOL

Plant Source
Ethanol is the by product of anaerobic cellular respiration. Various plants are used in the production of ethanol including grapes, wheat, barley and potatoes.

Action
Ethanol is a central nervous system depressant and has significant psychoactive effects in sub-lethal doses. Ethanol acts by binding to receptors for the neurotransmitter called GABA, increasing the inhibitory effect of the neurotransmitter.

Medical use
Ethanol is commonly used as a preservative and antiseptic agent.

Negative effects
Long-term use of alcohol in excessive quantities is capable of damaging nearly every organ and system in the body. The developing adolescent brain is particularly vulnerable to the toxic effects of alcohol. Damage to the central nervous system and peripheral nervous system can occur from sustained alcohol consumption.

10. Compare the brain scans of an alcoholic’s brain to that of a non-alcoholic’s brain.

10a: Describe what has happened to the alcoholic’s brain? Why has this happened?

IT HAS SHRUNKEN DUE TO NEURONAL CELL DEATH- OR ANY OTHER REASONABLE ANSWER

10b: How do you think this might affect the alcoholic’s memory, ability to think clearly and overall brain function?

ALL OF THESE WILL BE NEGATIVELY EFFECTED- OR ANY OTHER REASONABLE ANSWER

10c: If an alcoholic stopped drinking do you think they could re-grow the neurons that have died and recover normal brain function?

NEURONS DON’T TEND TO REgenerate AND ALTHOUGH STOPPING DRINKING MAY IMPROVE THEIR BRAIN FUNCTION IT WILL NEVER RETURN TO NORMAL OR TO THE WAY IT WAS BEFORE ALL OF THE DRINKING- THIS IS PERMANENT damage.
OPIATES
(MORPHINE, HEROIN)

Plant Source
Morphine and codeine come from the opium poppy. Codeine and heroin can be synthetically made from morphine.

Action
Mimics bodies own endorphins and binds to opioid receptors.

Medical use
Pain killers – nervous system depressants

Negative effects
Constipation, highly addictive, terrible withdrawal symptoms, alters gene expression, decreases the immune response.

11. Compare the brain scans of a heroin user’s brain and that of a non-user.

11a: Is blood flow increased or decreased in the heroin user’s brain?
DECREASED

11b: What does this tell us about the level of brain activity in the heroin user’s brain? Is it increased or decreased?
DECREASED

11c: Why do you think good blood flow is so important for the brain?
THE BRAIN NEEDS LOTS OF ENERGY- BLOOD FLOW BRINGS ALL THE SUGARS AND OXYGEN NEED TO MAKE THE ENERGY NEEDED

11d: What do you think the consequences of reduced blood flow in the brain might be?
MEMORY, THOUGHT, BEHAVIOUR, MOOD PROBLEMS etc- WHAT EVER THE STUDENTS COME UP WITH
COCAINES

Plant Source
Cocaine is obtained from the leaves of coca plant indigenous to South America. The leaf is almost universally chewed by some native communities.

Cocaine is psychoactive and highly addictive. It increases alertness, feelings of well-being, euphoria, energy, motor activity, feelings of competence and sexuality.

Action
Stimulates the nervous system and acts as a serotonin-norepinephrine-dopamine reuptake inhibitor.

Medicinal uses
It is used as an analgesic (pain killer) and in morphine addiction.

Negative effects
Cocaine use produces anxiety, paranoia and restlessness, tremors, convulsions and increased body temperature.

12. Compare the brain scans of a cocaine user’s brain and that of a non-user.

12a: What effect does cocaine have on brain activity?
BRAIN ACTIVITY DECREASED

12b: Do you think a cocaine user is going to be able to think clearly and make rational decisions?
NO

12c: Cocaine molecules block (inhibit) the re-uptake of dopamine. Would you expect the reward pathway to have more or less dopamine stimulation?

MORE TO START OFF WITH-

IF THEY ARE REALLY THINKING THEY WILL QUESTION IF THIS IS SO WHY IS THE BRAIN ACTIVITY DECREASED
THIS IS BECAUSE AFTER THE COCAINE USE THE BRAIN RESPONDS TO THE OVERSTIMULATION BY DECREASING ACTIVITY
TETRAHYDROCANNABINOL
(CANNIBIS, MARIJUANA)

Plant Source
Tetrahydrocannabinol is the main psychoactive molecule found in the cannabis plant.

Action
Tetrahydrocannabinol is a nervous system depressant: the molecule acts on natural cannabinoid receptors.

Medical Use
Cannabis has a long history of medicinal use dating back 12,000 years. It has been used for pain relief, appetite stimulation, and treatment of nausea and as an anti-inflammatory.

Negative effects
Prolonged use causes altered memory function, lethargy, anxiety, hallucinations, cancer and heart disease due to the drug being inhaled via smoking. Recent evidence suggests prolonged use may trigger psychosis in some users.

13a: What do the brain scans of a cannabis user and an Alzheimer's sufferer have in common?
HOLES SHOWING DECREASED BLOOD FLOW OR DECREASED BRAIN ACTIVITY

13b: Is the blood flow increased or reduced to the brain of a cannabis user?
DECREASED

13c: What symptoms would a cannabis user and Alzheimer sufferers have in common? Explain your reasoning.
DECREASED BLOOD FLOW MEANS DECREASED BRAIN ACTIVITY AND THEREFORE POSSIBLE MEMORY, BEHAVIOUR AND THINKING PROBLEMS
NICOTINE

Plant Source
Nicotine is a psychoactive drug sourced from a family of plants commonly known as “nightshades”. The tobacco plant is the most common source of nicotine.

Action
Nicotine is interesting as it can act as both a stimulant (increases neuron activity) and depressant (decreases neuron activity) of the nervous system depending on how much there is. At low doses it acts as a stimulant. At high doses it acts as a depressant.

Medical Use
Nicotine is used to treat epilepsy. It has also been shown to reduce the risk of some cancers. Nicotine increases concentration and memory, induces calmness, suppress the appetite, aids in pain relief and decreases anxiety.

Negative effects
These are mostly due to the way nicotine is taken through smoking and include heart disease, lung cancer and stroke.

14. Compare the body scans of a non-smoker and that of a smoker.

Nicotine also affects the activities of many important chemicals in our bodies called metabolites. These substances are important for growth and development. The scan compares the activity of an important metabolite in a non-smoker to that in a smoker.

14a: Does the body scan show an increased or decreased level of activity for the smoker?
DECREASED

14b: Is the brain the only organ affected by smoking? What other organs are affected?
NO- lungs, heart, liver, kidneys
Extension questions

Each neuron can receive chemical signals in the form of neurotransmitters from a large number of other neurons. These neurotransmitters may either stimulate or depress the activity of the post synaptic neuron. For example when dopamine acts on its receptor it stimulates the generation of an electrical signal in the post-synaptic neuron by exciting it. Whilst other neurotransmitters such as GABA actually inhibit the generation of an electrical signal in the post synaptic neuron, that is they depress the activity.

It is a matter of adding the stimulatory (+) and inhibitory (−) signals together to determine whether chemical signals will result in the generation of an electrical signal in the post synaptic neuron.

Pre-synaptic neuron A uses the neurotransmitter GABA
Pre-synaptic neuron B uses the neurotransmitter Aspartate
Pre-synaptic neuron C uses the neurotransmitter Glutamine
Pre-synaptic neuron D uses the neurotransmitter Glycine

Glutamine and Aspartate are excitatory or stimulatory neurotransmitters
GABA and Glycine are inhibitory or depressive neurotransmitters
Place a negative or positive symbol next to the Axon labels for each pre-synaptic neuron depending on whether the neurotransmitter it uses is stimulatory (+) or inhibitory (-). This will help you answer the following questions.

Assuming that each neurotransmitter acts on the neuron with the same level of strength can you determine which of the following scenarios will result in the generation of an electrical signal in the post synaptic neuron?

- **Axon A + B + C** send their corresponding chemical message to the post-synaptic neuron.
  - Would an electrical signal be generated in the post-synaptic neuron? Yes / No

- **Axon A + C + D** send their corresponding chemical message to the post-synaptic neuron.
  - Would an electrical signal be generated in the post-synaptic neuron? Yes / No

- **Axon D + B + C** send their corresponding chemical message to the post-synaptic neuron.
  - Would an electrical signal be generated in the post-synaptic neuron? Yes / No

- **Axon A + D** send their corresponding chemical message to the post-synaptic neuron.
  - Would an electrical signal be generated in the post-synaptic neuron? Yes / No

- **Axon A + B** send their corresponding chemical message to the post-synaptic neuron.
  - Would an electrical signal be generated in the post-synaptic neuron? Yes / No

- **Axon B + C** send their corresponding chemical message to the post-synaptic neuron.
  - Would an electrical signal be generated in the post-synaptic neuron? Yes / No

- **Axon D + C** send their corresponding chemical message to the post-synaptic neuron.
  - Would an electrical signal be generated in the post-synaptic neuron? Yes / No

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**Neurological diseases**

Neurologic diseases are disorders of the brain, spinal cord and nerves throughout your body. Together they control all the workings of the body. When something goes wrong with a part of your nervous system, you can have trouble moving, speaking, swallowing, breathing or learning. You can also have problems with your memory, senses or mood.

**Parkinson’s Disease**

Parkinson's disease is a disorder that affects nerve cells, or neurons, in a part of the brain that controls muscle movement. No one knows what damages these cells. Symptoms of Parkinson's disease may include

- Trembling of hands, arms, legs, jaw and face
- Stiffness of the arms, legs and trunk
- Slowness of movement
- Poor balance and coordination
As symptoms get worse, people with the disease may have trouble walking, talking or doing simple tasks. They may also have problems such as depression, sleep problems or trouble chewing, swallowing or speaking.

In Parkinson's, neurons that make a chemical called dopamine die or do not work properly. Dopamine normally sends signals that help coordinate your movements.

What kind of treatment do you think might be used to treat Parkinson's Disease?

Give the patient dopamine or a drug that mimics dopamine and is able to act on dopamine receptors.

Stem cells to replace the dopamine producing neurons - has not been shown to effective because this is a degenerative disease and even if it initially works the neurons that are replaced using the stem cells end up dying.

Schizophrenia

Many studies have investigated the possible role of brain neurotransmitters in the development of schizophrenia. Most of these studies have focused on the neurotransmitter called dopamine. The "dopamine theory of schizophrenia" states that schizophrenia is caused by an overactive dopamine system in the brain.

In light of this theory what kind of treatment do you think may be effective in treating the symptoms of Schizophrenia? Specifically how would the drug target neurons?

Decrease dopamine stimulation of neurons. Block the dopamine receptors on the post-synaptic neuron.

Given what has been discussed above regarding Parkinson’s Disease what might be some of the negative side effects of this treatment?

In Parkinson’s we see decreased dopamine levels and therefore by inhibiting dopamine stimulation of neurons we may see some Parkinson's like symptoms.

It should be noted that whilst there is very strong evidence for the "dopamine theory of schizophrenia" there is also evidence that does not support it and there are a wide range of other factors involved in the disorder, including changes in serotonin neurotransmission.