Small-Group Guided Inquiry:
How Drugs Work

Before you begin, consider what you already know:

1. In your own words, define what a "**drug**" is.

2. **Why do you think** people use drugs?

3. How does the **brain** work as the human body's "**control center**?"

Part 1

Read the background article, "How Drugs Work," and answer these questions about the chemistry of drug molecules:

4. How long do **historians** and **archeologists** believe humans have been using **drug-like substances**?

5. Summarize how humans in **ancient societies** used drugs.

6. What is the **most widely used drug in the world** today? What is its **chemical name**?

7. The end of the article's first section ("Where do drugs come from?") mentions the **importance of "synthetic molecules."** What is a synthetic molecule? In your own words, explain how this "**major new development**" has **changed the world**.

8. **What is the difference** between a "**medicine**" and a "**drug**"?

9. How could **caffeine** be considered a drug?

10. **Think of an example** of a **common legal substance** that could be considered a drug. Explain how this definition would apply.

11. The first paragraph of the third section ("Who uses illegal drugs?") outlines some **statistics about drug use in the United States** and North America.

    Summarize this paragraph in **1 sentence**.

    Which piece of information in this paragraph makes the **strongest impression** on you? **Why?**

    List **2 specific questions** you have after reading these statistics.

12. **Why is it important** to know that **China** and **India** do not keep **reliable statistics on illegal drug use**? Why do you think **many African nations** do not have **clear data** about illegal drug use within their country?

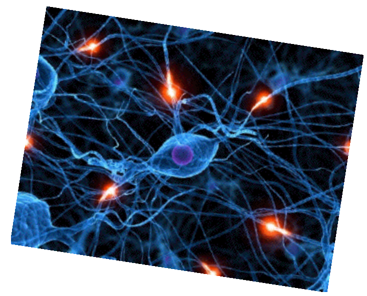
13. **Why do you think** "**bath salts**" are so appealing to **young people**? What makes them **dangerous**?

14. **Generally**, how do drug molecules **affect the human body**?

15. What **role** does the **three-dimensional shape and structure of a drug molecule** play in determining its effects? (Use the terms **receptors** and **neurotransmitters**.)

16. **In your own words**, why are drugs dangerous?

Watch the first video segment, "Brain Chemistry," to see how drug molecules interact with our body to change the way our brain is working.



17. The video begins with some important visuals from **inside the human brain**. Answer the questions below about how **nerves** and **neurons** work in our **brain**:

    What do **nerves** do?

    What are **neurotransmitters** and what do they do?

    Draw a **diagram** of a **nerve synapse**. Label the following: presynaptic neuron, postsynaptic neuron, synaptic cleft, vesicles, neurotransmitters, neurotransmitter transporters, and neurotransmitter receptors.

18. The video continues to explain how the nerves actually **communicate throughout the body**:

    In your own words, **explain** how nerves use **neurotransmitters** to **send messages** from neuron to neuron, and around the body. (If you need more help with **how nerves send chemical messages**, try this explanation and video from BBC.)

Name 2 **neurotransmitter molecules** scientists have found in the human brain. Tell what **chemical message** each neurotransmitter is thought to send.

19. The video shows an example of a drug molecule – **methamphetamine hydrochloride** – and explains how it **interrupts the brain's communication process**:

    What is the role of **dopamine** in the human body?

    Summarize how **meth changes the dopamine communication pathway** in the brain?

    What makes **meth** so **addictive**?

Go to the [first weblink] to see how specific drugs impact the human body and our brains. Follow the instructions below and answer the questions to record the most important information.

20. Start by listening to Dr. Glen Hanson's introduction to the **basic chemistry of drug abuse**. Click [listen] and answer the questions below:

    What do **all drugs of abuse** have **in common**?

    Dr. Hanson explains the role of **dopamine** in the human brain. In your own words, **explain** why a person might want to **use drugs repeatedly**, in terms of their **chemistry**.

Use the same website to gather more information about specific drugs of abuse, their effects, and how they work in the human body.

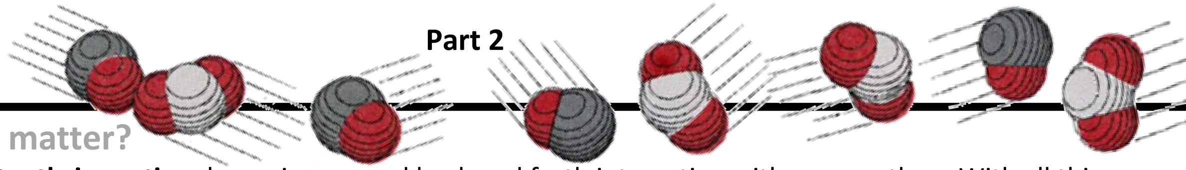
You *might* want to divide the next few steps among your group.

Warning! Make sure **everyone** has access to **all** of the information from this website.

It will be very important as we continue focusing on **teen drug use** and **brain chemistry**.

21. Click on "**Explore! Drugs of Abuse**." This area of the website introduces you to 12 different categories of drugs. Fill in the **"Drugs of Abuse" chart** to organize important information about each drug. (**Make sure to include *how* the drug is taken *into* the body**.)
22. In the space below, **name 1 other substance that could be called a "drug of abuse"** that is not mentioned on the website. Explain **why you think it could be a "drug of abuse"** and **why you think the website doesn't include it**.
23. From the original website, click on "**Explore! Mouse Party**." This area of the website simulates an animal testing lab that shows **some of the major drugs of abuse *in action***. Fill in the **"Mouse Party" chart** to organize how each drug impacts the **chemistry of the human brain**.
24. In your own words, **summarize** how any drug molecule is **taken into the human body** and **influences the brain**, and how that leads to its **effects**. **Use several well-written sentences and a diagram to support your work.**
25. On the original website, spend some time looking at the **other resources**. There are links to games, demonstrations, and explanations of **how drugs get into the human body**, their **long-term impact on the brain**, and the process of **addiction**. Use the space below to make notes of important information:

Part 2



Read this next!

Why does shape matter?

All particles are constantly in motion, bouncing around back and forth interacting with one another. With all this movement, the particles tend to bump into one another. **When two particles hit each other, it's called a "collision."** This is where the real action happens! ***If*** **two particles hit each other in the right way and *if* they hit each other hard enough (with enough energy), a chemical reaction *might* take place.** If all of these things happen correctly, the collision is "effective," meaning that a chemical change is possible. But it takes a lot of work to make that chemical change actually happen… It's kind of a miracle that reactions happen at all!

Because of all these requirements for collisions to be effective, the shape of the molecule plays a *huge* role in whether or not a chemical reaction can happen. **For any molecule to do its job, it must have the right shape.** The shape is determined by interactions of electrons inside the molecule.

What controls a molecule's shape?

The shape of a molecule is a critical factor in what it can do. A molecule's shape is determined by its electrons.

The electrons are constantly caught in a balancing act. Electrons are negatively charged. The nucleus of all atoms is positively charged. So, the electrons are attracted to the nucleus. But they are also repelled by one another. **This forces the electrons stay as close to the nucleus as they can, and also spread out from the other electrons as much as possible.** (Chemists call this "**VSEPR Theory**.") If they fall out of balance, the entire atom could become unstable…

However, the electrons have found the answer! There are a few **specific arrangements** that make everybody happy – the electrons get to be close to the nucleus and spread out from one another, *and* the whole atom gets to be stable. These arrangements, called "**molecular geometries**," give rise to some special molecular shapes. The shapes, in turn, give rise to the phenomena we see in everyday life: from drugs that fight diseases to the way we need to cook our foods.

What do the molecular shapes look like?

These same special shapes show up in every chemical compound in the universe. They are called "molecular geometries."

Adapted from "Molecular Geometry" by Concord Consortium

Watch the second video segment, "VSEPR Theory and Molecular Geometry," to find out more.

(Use your **Chemistry Help Guide** for molecular geometry to help you keep track of important information in this video.)

Answer the following questions about molecular shapes:

26. Summarize the **VSEPR theory** in your own words.

27. Chemists have identified **at least 18 different molecular geometries** that show up in different chemical compounds.

    How many of these will **we be focusing on** in our class? **What are they called?**

    Find **at least 2 other molecular geometries** that exist naturally. Write their **names** and draw an **image** for each one below:

Using a model kit, build several three-dimensional models of simple molecules to see how their molecular geometry actually looks.

28. Build a model of each of the substances listed in the **"Molecular Models" chart**. Fill in the chart to organize important information about each molecule and determine its molecular geometry.
29. **Propane**, C_3H_8, is a hydrocarbon fuel used in small, portable gas tanks (like gas grills or camping supplies).

    Draw a Lewis structure for propane.

    In your diagram, circle each atom that **shares more than 1 bond**.

Read this next!

Larger molecules tend to have **more than 1 "central atom."** Each central atom **has its own molecular geometry** and its own chemistry. The molecule's overall shape and the location of its central atoms will determine its **properties**, **stability**, and **behavior**.

30. Any atom that shares more than 1 bond is a "central atom." For each of the central atoms in propane, **label their molecular geometries**.

Go to the third weblink to look at how the molecular geometries show up in some common molecules. Use the links, information, and graphics to fill in the chart and answer the questions below.

31. The website lists links to **three-dimensional images of many different common chemical substances**, from **fuels and foods** to **drugs and dyes**. In the drugs section, there are many medicines as well as illicit drugs. **Aspirin, Tylenol, and Ibuprofen are all common house-hold medications for pain.** Use the links to look at their chemical structures and fill in important information in the chart:

Molecule	Aspirin	Tylenol	Ibuprofen
Chemical name			
Molecular formula			
2D structure			
3D structure			

32. What is the name of the **group of medicines** that Aspirin, Tylenol, and Ibuprofen all belong to? Generally, **what do these medicines do** for our bodies?

33. What **similarities and differences** do you see in these molecules' **chemical structures**?

34. Using a modeling kit, **build a 3D model of each of these molecules**.

    Take a picture of each molecule that shows all of its atoms, bonds, and shapes.

    Find at least **one example of each of the 6 major molecular geometries** in the models you have built. **Take a picture of each shape.**

    In the diagrams in your chart from question 31, **circle and label the examples** of the molecular shapes you have found.

Read this next!

(Use your **Chemistry Help Guide** for polarity to help you understand important background information for this next section.)

A molecular balancing act…

Polarity is all about balance. **Polarity refers to the balance between positive charges and negative charges** in and around a molecule. When the charges don't really balance out, the **electrons** tend to get **pushed** and **pulled** around… This **stress** ends up making the molecule **less stable**. So, **polar molecules are always more reactive than nonpolar molecules**.

When atoms in a molecule don't share electrons evenly, they form polar bonds. If a molecule has enough polar bonds, it might **throw off the balance** of the entire structure. **Nature does a pretty good job** of keeping everything in balance. In a large molecule, a few polar bonds can't make a big difference; But in smaller molecules, a little polarity can go a *long* way…

Polar personalities

Most molecules in nature are polar (or at least *kind of* polar). And most of the time, molecules are **only polar in certain areas**... especially in large molecules like medicines, drugs, or food compounds. These polar "regions" are called "**polar centers**."

The polar center (or center*s*) of a large, complicated molecule is **where all the action will take place**. This is where **chemical reactions** get started, and this is the part of the molecule that has to **collide effectively** for those reactions to ever have a chance!

If the molecular geometry around a polar center makes effective collisions difficult, the molecule might never get the chance to actually react. **But if the geometry of a polar center makes effective collisions easier**, the molecule will probably react more often and more quickly.

35. **A central atom is polar is if it has unshared electrons or if its bonds are not symmetrical.** In the diagrams in your chart from question 31, **put a square around all of the polar centers** in Aspirin, Tylenol, and Ibuprofen.

From the original website, use the links to look at three-dimensional structures for some other common molecules. Follow the instructions below.

36. Follow the links to look at examples of other medicines and drugs, food substances, and other biological compounds. Choose at least 3 that are of special interest to you and record them in the chart below. (*Warning!* A few of the links do not work. Your teacher can help you find information about these molecules.)

    Fill in this chart with important information about each molecule you choose.

Molecule			
Chemical name			
Molecular formula			
What is this molecule **used for**? What are its **effects**? How was it **discovered**? How do **people have access** to this substance?			
2D structure			
3D structure			
What role does **polarity** play in this molecule's chemistry?			

37. **Choose 1 of these interesting molecules that you might want to study more.** If you are especially interested in a molecule that is not listed on the website, ask your teacher for help finding other resources. (You can choose to focus on this in your unit project if you want.)

38. So far you have learned about **medicines and drug molecules**, how they **interact** with the **human brain's communication system**, and how the **bonding** and **shapes** within these molecules impact their **properties**. The chemical processes inside the human body are called the "**metabolism**." **The way a chemical compound interacts with and changes the body's metabolism is called its "metabolic impact."** In your own words, **explain the connections** between **bonding**, **molecular geometry**, and **polarity** and **the way a drug molecule works in your body** (its metabolic impact).

Molecular Models

Substance		Structure					
Chemical Name	Molecular Formula	Lewis Structure (2D Drawing)	Total number of **“electron zones”** around the central atom	Number of **bonding “zones”** around the central atom	Number of **lone pairs** of electrons around the central atom	**3D Drawing**	**Molecular Geometry**
Methane (carbon tetrahydride)							
Ammonia (nitrogen trihydride)							
Water (dihydrogen monoxide)							
Carbon dioxide							
Elemental chlorine							
Elemental oxygen							