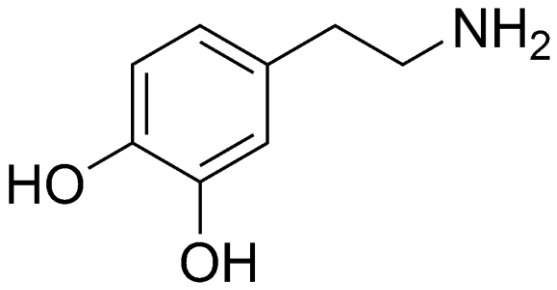
The Chemistry of Cocaine

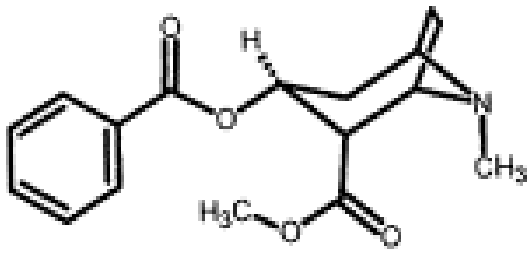
Part 1

Professor Martinez entered the classroom with a livelier step than usual. Her morning students were accustomed to their instructor's ritual of carefully unpacking her book bag and arranging the contents neatly on the desk before beginning a lecture. But this time Martinez simply set her bag down on the chair, turned to the class, and began.

"Today, I want to share with you something exciting that I was reading about cocaine and dopamine."

The room grew suddenly silent. The word "exciting" was not one that students usually associated with Professor Martinez's lectures. The class looked intently at the blackboard as she drew the following reaction scheme.





Questions

1. Which compound is cocaine and which is dopamine?
2. How are they similar? How are they different?

Part 2

"Dopamine is a neurotransmitter that acts brain processes that control movement, emotional response, and ability to experience pleasure and pain. Dopamine (like other neurotransmitters) is reabsorbed and recycled, and this serves to regulate the level of neurotransmitter present in the synapse—the gap between neurons. Specific transport proteins bind to neurotransmitters and facilitate their reuptake," Professor Martinez explained.

"Professor Martinez, what does dopamine do?" one of the students asked.

Question

3. Answer the student's question about dopamine.
4. Looking at your answer to question 2, why might cocaine act like dopamine? How does this related to structure and function?

Part 3

"When your brain sends signals, it uses chemicals like dopamine to continue the message. Dopamine binds to a receptor on a neuron after the synapse. This makes the stimulated neuron experience an action potential and the message keeps going. After the message is sent, dopamine is drawn back up into the cell that sent it through a protein called dopamine active transporter, DAT. When cocaine is introduced into the blood stream, it must pass the blood brain barrier," continued Professor Martinez.

Question

5. Using the internet, find out why cocaine can cross this barrier.
6. What does someone who takes cocaine experience?

"Cocaine prevents dopamine reuptake by binding to its transport protein. As a result, more dopamine remains to stimulate neurons, and this causes prolonged feelings of pleasure and excitement. Cocaine's effects on the central nervous system peak within minutes of consumption. As such, rapid reduction of the concentration of cocaine (to a form with less activity) in the blood is a key strategy to fighting overdose in humans," Professor Martinez continued.

Question

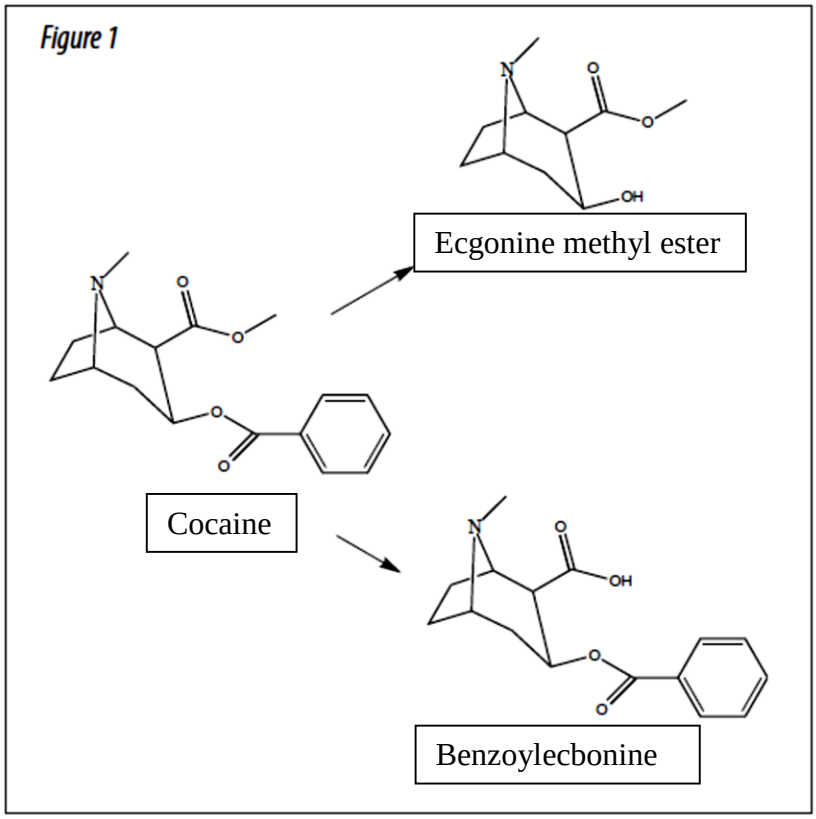
7. How does cocaine prevent the reuptake of dopamine into DAT?

Part4

"How does cocaine get broken down?" another student asked.

"Well, cocaine has two ester functionalities. Hydrolysis of the benzoyl ester yields ecgonine methyl ester (EME) and hydrolysis of the methyl ester yields benzoylecgonine (BE). An enzyme in the blood, butylcholinesterase (BChE), catalyzes the hydrolysis of benzoyl ester and this is believed to be the major metabolism pathway for cocaine in vivo. In addition, two liver enzymes (denoted by hCE-1 and hCE-2) catalyze hydrolysis at the methyl ester and the benzoyl ester, respectively. EME is less active than cocaine and is believed to cause vasodilatation. BE, on the other hand, appears to be similar to cocaine and causes vasoconstriction as well as lowers the seizure threshold. The researchers developed a mutant form of BChE, which they found could metabolize cocaine 2,000 times faster than the body's natural version of that enzyme. The enzyme that they developed was shown to also prevent convulsions and death when injected into mice that had been given overdoses of cocaine."

She drew the following molecular reaction on the board.



Questions

8. Where does this reaction happen?
9. What is vasoconstriction?

Part 5

Another student asked, "I had a cousin die of a cocaine overdose. What caused him to want more cocaine?"

Questions

10. Look up how cocaine influences the reward pathway, also called the pleasure center.
11. Is cocaine the only thing that influences this?

"I heard the drinking and doing coke is not good. Why is that?" the same student asked.

Questions

12. Use the internet to find out why mixing cocaine and alcohol is bad. Explain your research.
13. How long does cocaine stay in the body?