

**Teacher’s Guide**

**Caffeine: The Good, the Bad, and the Why**

***February 2024***

**Table of Contents**

[***Anticipation Guide***](#_1fob9te)***2***

Activate students’ prior knowledge and engage them before they read the article.

[***Reading Comprehension Questions***](#_3znysh7) ***3***

These questions are designed to help students read the article (and graphics) carefully. They can help the teacher assess how well students understand the content and help direct the need for follow-up discussions and/or activities. You’ll find the questions ordered in increasing difficulty.

[***Graphic Organizer***](#_9f8azrtnp6p5) ***5***

Thishelps students locate and analyze information from the article. Students should use their own words and not copy entire sentences from the article. Encourage the use of bullet points.

[***Answers***](#_djipzn7z1r1b) ***6***

Access the answers to reading comprehension questions and a rubric to assess the graphic organizer.

[***Additional Resources***](#_8qbtv1wio6jt) ***9***

Here you will find additional labs, simulations, lessons, and project ideas that you can use with your students alongside this article.

[***Chemistry Concepts and Standards***](#_gy1yjx1c39og) ***10***



# Anticipation Guide

**Directions: *Before reading the article*,** in the first column, write “A” or “D,” indicating your **A**greement or **D**isagreement with each statement. Complete the activity in the box.

As you read, compare your opinions with information from the article. In the space under each statement, cite information from the article that supports or refutes your original ideas.

| **Me** | **Text** | **Statement** |
| --- | --- | --- |
|  |  | 1. Caffeine affects neurons in the brain. |
|  |  | 2. Caffeine comes from a variety of plants. |
|  |  | 3. Caffeine, capsaicin, cocaine, and strychnine are all alkaloids, which contain nitrogen. |
|  |  | 4. Caffeine attaches to the same protein receptors as adenosine, a chemical that makes you feel tired. |
|  |  | 5. It takes the average person one hour to break down half of the caffeine they consume. |
|  |  | 6. It is impossible to become dependent on caffeine. |
|  |  | 7. Caffeine does not interact with other drugs. |
|  |  | 8. The American Academy of Pediatrics recommends that children under 12 should not consume caffeine in any form. |
|  |  | 9. An 8-oz. cup of black tea has more caffeine than a 16-oz. fountain Coca-Cola drink. |
|  |  | 10. People have been consuming caffeine in one form or another for thousands of years. |

# Student Reading Comprehension Questions

**Directions**: Use the article to answer the questions below.

1. What two chemicals in our body control how we feel?
2. What is the special characteristic that makes a molecule a member of the alkaloid group?
3. What characteristic makes a molecule a purine?
4. Where is the caffeine molecule typically found?
5. Define tolerance, and what happens to the body for it to achieve tolerance.
6. Look at the molecular structures on p. 8 of the article. Using those pictures, and your knowledge of Lewis structures, how many bonding sites does an atom of nitrogen have?
7. What is special about the caffeine molecule that allows it to replace adenosine on certain proteins?
8. Caffeine is used to make people feel “alert” and less sleepy. Specifically, what does the molecule do to the body’s chemistry to do this?
9. How does dopamine affect the human body? Can you think of other examples (either from previous knowledge, or some basic research) that affects dopamine in our bodies?
10. What happens when a person stops taking caffeine (both chemically and physically)? What is this term called?

**Student Reading Comprehension Questions, cont.**

**Questions for Further Learning**

***Write your answers on another piece of paper if needed.***

1. Perform online research on the differences between caffeinated and decaffeinated coffee. Explain the differences in production, and if there are any differences in taste, looks, etc.
2. Research and list some of the common effects caffeine has on the body. Explain any effects that could be potentially hazardous to a person.

# Graphic Organizer

**Directions**: As you read, complete the graphic organizer below to describe the chemicals mentioned in the article.

|  | **What it is** | **What it does** |
| --- | --- | --- |
| **Alkaloid** |  |  |
| **Caffeine** |  |  |
| **Adenosine** |  |  |
| **Dopamine** |  |  |

**Write three new things you learned about the safety of consuming caffeine:**

| **1** |  |
| --- | --- |
| **2** |  |
| **3** |  |

# Answers to Reading Comprehension Questions & Graphic Organizer Rubric

1. What two chemicals in our body control how we feel?  
   The two chemicals in our body that control how we feel are adenosine and dopamine.
2. What is the special characteristic that makes a molecule a member of the alkaloid group?  
   A molecule is considered to be a member of the alkaloid group if it has a nitrogen atom in its structure.
3. What characteristic makes a molecule a purine?  
   Purines are molecules with “fused rings”, one ring containing 6 atoms and the other 5 atoms. Nitrogen is a part of these fused rings.
4. Where is the caffeine molecule typically found?  
   The caffeine molecule is naturally occurring. It is commonly found in many different plants.
5. Define tolerance, and what happens to the body for it to achieve tolerance.  
   When your body gets used to a chemical, it undergoes tolerance, which means a person would need more of the chemical to achieve the same feelings.
6. Look at the molecular structures on p. 8 of the article. Using those pictures, and your knowledge of Lewis structures, how many bonding sites does an atom of nitrogen have?  
   According to the diagrams, the nitrogen atom can have 3 “bonding sites”, which means it can bond up to three times (either three single bonds, or 1 double bond and one single bond). In general nitrogen tends to have a lone pair of electrons and three bonds to complete its octet. The lone pair can also be involved as a Lewis base.
7. What is special about the caffeine molecule that allows it to replace adenosine on certain proteins?  
   The caffeine molecule and adenosine molecule are very similar in shape and structure. Because of this, the caffeine molecule will attach to the same protein receptors, which causes you to remain alert.
8. Caffeine is used to make people feel “alert” and less sleepy. Specifically, what does the molecule do to the body’s chemistry to do this?  
   The way caffeine makes people feel alert is by causing the blood vessels to constrict, and also increases activity in the nervous system. This causes the body to produce adrenaline which makes one feel more alert.
9. How does dopamine affect the human body? Can you think of other examples (either from previous knowledge, or some basic research) that affects dopamine in our bodies?  
   Dopamine is a chemical in the brain that encourages a person to seek desirable experiences. This provides a mental “reward system” that makes the body feel good. Other drugs can give the same feeling, as well as activities that a person enjoys, or seeing familiar people. (Which are healthier options).
10. What happens when a person stops taking caffeine (both chemically and physically)? What is this term called?  
    When too much caffeine is consumed, the body produces more adenosine and its receptors to compensate. With less/no caffeine, the body has too much adenosine, so it feels much less alert, for a longer period of time. This is typical with most other drugs that can be addictive.
11. Perform online research on the differences between caffeinated and decaffeinated coffee. Explain the differences in production, and if there are any differences in taste, looks, etc.  
    Decaffeinated coffee or other drinks are not 100% caffeine free (it’s approximately 97% free). The beans are chemically “washed” to eliminate the caffeine. The taste and color could be different, but the nutritional value should still be the same. (<https://www.healthline.com/nutrition/decaf-coffee-good-or-bad#How-much-caffeine-is-in-decaf-coffee>)
12. Research and list some of the common effects caffeine has on the body. Explain any effects that could be potentially hazardous to a person.   
    Caffeine can cause insomnia, nervousness, restlessness, nausea, increased heart rate, and other side effects. It could take 4-6 hours for the caffeine to break down to normal levels in the body. Larger doses of caffeine can cause headaches, anxiety, and chest pain in some people. In very high doses, caffeine can cause irregular heartbeat and even death from complications.  
    (<https://www.webmd.com/vitamins/ai/ingredientmono-979/caffeine>)

**Graphic Organizer Rubric**

If you use the Graphic Organizer to evaluate student performance, you may want to develop a grading rubric such as the one below.

| **Score** | **Description** | **Evidence** |
| --- | --- | --- |
| 4 | Excellent | Complete; details provided; demonstrates deep understanding. |
| 3 | Good | Complete; few details provided; demonstrates some understanding. |
| 2 | Fair | Incomplete; few details provided; some misconceptions evident. |
| 1 | Poor | Very incomplete; no details provided; many misconceptions evident. |
| 0 | Not acceptable | So incomplete that no judgment can be made about student understanding |

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# Additional Resources and Teaching Strategies

**Additional Resources**

* **Lessons and lesson plans**
* ChemMatters: Coffee: Brain Booster to Go?  
  <https://teachchemistry.org/chemmatters/december-2008/coffee-brain-booster-to-go>
* ChemMatters: Chocolate—How Sweet It Is!  
  <https://teachchemistry.org/chemmatters/december-1999/chocolate-how-sweet-it-is>
* Open for Discussion: Caffeine

<https://www.acs.org/education/resources/highschool/chemmatters/past-issues/archive-2013-2014/caffeine.html>

* **Projects and extension activities**
  + Compound Chemistry: Arabica vs Robusta

<https://www.compoundchem.com/2018/09/30/arabica-robusta/>

* + Compound Chemistry: How is decaffeinated coffee made?

<https://www.compoundchem.com/2018/09/26/coffee-decaffeination/>

* + YouTube: How Does Coffee Keep You Awake

<https://youtu.be/foLf5Bi9qXs?si=GTm0nps4I8ebCy9Z>

* + AsapScience: Your Brain On Coffee

<https://youtu.be/4YOwEqGykDM?si=ewstspoJ6D9tfqVu>

* + What’s The Buzz About Caffeine? | Serving Up Science

<https://www.pbs.org/video/whats-the-buzz-about-caffeine-serving-up-science-bzohvp/>

**Teaching Strategies**

Consider the following tips and strategies for incorporating this article into your classroom:

* **Alternative to Anticipation Guide:** Before reading, ask students if they enjoy drinks containing caffeine, and how the drinks make them feel. Ask if they have ever thought about the chemistry involved in consuming caffeine. Their initial ideas can be collected electronically via Jamboard, Padlet, or similar technology.
  + As they read, students can find information to confirm or refute their original ideas.
* After they read, ask students what they learned about the effects of caffeine on their bodies. Ask how they might use the information in the future.
* Consider showing the ACS Reactions Video “The Science of Caffeine: The World’s Most Popular Drug” (2:25): <https://youtu.be/YuJOhpNS0IY?si=0pZq2PaXBryXyCtU>. The video includes information from the article, as well as graphics to enhance understanding.

# Chemistry Concepts and Standards

**Connections to Chemistry Concepts**

The following chemistry concepts are highlighted in this article:

* Molecular structure
* Functional groups
* Pharmaceuticals

**Correlations to Next Generation Science Standards**

This article relates to the following performance expectations and dimensions of the NGSS:

**HS-LS1-6.** Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules.

**Disciplinary Core Ideas:**

* PS.1.A: Structure and Properties of Matter
* LS.1.A: Structure and Function

**Crosscutting Concepts:**

* Cause and effect
* Structure and function
* Stability and change

**Science and Engineering Practices:**

* Obtaining, evaluating, and communicating information.

**Nature of Science:**

* Scientific knowledge assumes an order and consistency in natural systems.

See how *ChemMatters* correlates to the[**Common Core State Standards** online](https://www.acs.org/content/acs/en/education/resources/highschool/chemmatters/teachers-guide.html).