ChemMatters®

Demystifying Everyday Chemistry

Teacher's Guide

October 2025

www.acs.org/chemmatters

ACS Chemistry for Life®

October Teacher's Guide Introduction

The October 2025 issue of ChemMatters relates to the National Chemistry Week theme: The Hidden Life of Spices. More information can be found here.

This issue provides engaging information about the chemical senses of taste and smell. The articles, all related to food, will help students learn more about the relevance of chemistry in their lives. Students may be surprised to learn that food chemists may work with law enforcement as well as top chefs around the world.

For all of the articles, encourage students to think about how science is done, how we know what we know, and how chemistry connects to their lives.

Notes regarding this issue:

- Here is a quick activity to encourage students to think about how small the molecules responsible for taste and smell really are. If you do this, be aware of possible student allergies. Prior to class, number some brown paper lunch bags and place smelly things inside (a crushed garlic clove, a crushed fragrant flower, cinnamon powder, some onion slices, a cut lemon, etc.). Staple or tape the bags closed. Pass the bags around and ask students to describe the contents of each bag without peeking inside. Ask them how they know, and how the information got to their noses.
- Most students will be very familiar with at least some of the spices described in the articles. For each spice, ask students to relate their prior experience with the spices to what they learn from the reading.

Teaching Ideas for this issue:

1. "Open for Discussion" on pages 3 and 4 includes information about cilantro, which some people find disgusting. Prior to reading, you might ask students if they like cilantro, or if they find it disgusting. Ask students to provide reasons for their choice. As they read, they can look for more information to support or refute their original ideas about cilantro. After reading, ask them what they learned about cilantro and how they might use that information in the future. The ACS Reactions video "Why Do Some People Hate Cilantro?" (2:47) has similar information to reinforce the reading.
2. "Quick Read: Why Do Cats Go Wild for Catnip?" on page 17 describes the chemistry of catnip. Prior to reading, ask students if they have ever seen a cat that has been exposed to catnip. Ask them to describe the cat's behavior. As students read the article, encourage them to look for information about the chemistry of catnip, and how cats might benefit from rubbing catnip on their fur.
3. "Nano Reads" on page 18 describes current research related to the chemistry of taste and smell.
4. The "Chemistry in Person" column on page 23 describes the work of a food chemist, and the tools she uses for research.
5. Consider assigning a team of students to read each feature article, then present what they learned in a podcast, PowerPoint or similar presentation, poster or brochure, or some other engaging format.
    - Prior to reading the article, give students the Anticipation Guide for the article along with the graphic organizer and links to other information provided.
    - Be sure to ask students to include information providing evidence for the claims made in the article.
6. Alternatively, students can create concept maps about the important chemistry concepts in the article they choose.

5E Lesson Ideas for individual articles:

Engage	Provide the Anticipation Guide or ask a thoughtful question (see the individual Teacher's Guide for each article) to engage students in the reading. Students should record their initial ideas individually, in pen, so they can't be erased. Students can then discuss their initial ideas in small groups or as a whole class.
Explore	Students read the article to discover more about the concepts in the article. During this phase, students will revisit their beginning ideas and record how the information in the article supports or refutes their initial ideas, providing evidence from the article.
Explain	Students answer questions and/or complete the graphic organizer provided for each article, then discuss their learning with their classmates. Students should recognize the evidence for the claims made in the articles, and how the evidence supports the claims.
Elaborate	Students can pose questions for further study. For some articles, there are related ACS Reactions videos students can watch to learn more about the concepts presented. See the individual Teacher's Guide for each article to learn more.
Evaluate	Students write a short summary of what they learned that describes how it connects to their lives. Students may also present their learning to their classmates or others. Here is a template for an exit slip: ● I used to think… ● But now I know… ● And this is how I learned it…

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Demystifying Everyday Chemistry

Teacher's Guide

Spice Fakes and Frauds

October 2025

Table of Contents

Anticipation Guide

Name: _____

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. Chili powder contains dried chile pepper.
		2. Spice fraud costs the food industry less than $1 billion each year.
		3. Most spices can be grown in the United States.
		4. Food chemists use untargeted testing, with no specific impurity in mind.
		5. Spice buyers use handheld spectrometers when buying spices.
		6. Plant pigments can be separated using chromatography.
		7. Saffron is the most expensive spice in the world.
		8. X-ray fluorescence (XRF) does not damage spice molecules.
		9. More oregano is adulterated now than 12 years ago.
		10. Some spice imitations are accepted.

Student Reading Comprehension Questions

Name: _____

Directions: Use the article to answer the questions below.

1. What is spectroscopy?
2. What is XRF?
3. How does chromatography work?
4. What is economically motivated adulteration (EMA), and why are spices vulnerable?
5. How do targeted and untargeted testing differ?
6. How does near-infrared spectroscopy (NIRS) help find fake spices?
7. Why might XRF miss some adulterants that NIRS can flag?
8. How can chromatography reveal illegal dyes in turmeric or chili powder?
9. What simple tests can raise suspicion of spice fraud?
10. Why is saffron often adulterated, and how can you spot fakes?
11. What happened in the Bangladesh turmeric case?
12. What's the difference between cassia and Ceylon ("true") cinnamon?
13. What are acceptable substitutes for vanilla, and why?
14. Why are handheld instruments important in the spice trade?
15. What's the consumer takeaway about spice safety?

Graphic Organizer

Name: _____

Directions: As you read, complete the graphic organizer below to describe how adulterated spices can be detected.

	What it is/How it works	Advantages	Disadvantages	What is it used to detect
NIRS				
XRF				
Chromatography				
Low-tech testing	**Examples:** **1.** **2.** **3.**			

Summary: On the back of this paper, write a short text to a friend explaining why spices might be adulterated, and how adulterated spices can be identified.

Answers to Reading Comprehension Questions & Graphic Organizer Rubric

1. What is spectroscopy?
   Spectroscopy is the study of how matter interacts with light; different bonds and elements absorb or emit specific wavelengths of light, creating a "spectrum" that helps identify what a sample contains.

2. What is XRF?
   X-ray fluorescence (XRF) uses X-rays to excite electrons so they move up in energy level, when they fall back to their normal energy, they emit secondary X-rays. The energies of those emissions reveal which elements are present, making XRF especially useful for detecting metals like lead and chromium.

3. How does chromatography work?
   In chromatography a mixture moves with a mobile phase over a stationary phase; components travel at different speeds based on their attractions and solubilities, separating into distinct bands or spots.

4. What is economically motivated adulteration (EMA), and why are spices vulnerable?
   EMA is adding cheaper materials or substitutes to increase profit; spices, which can be quite expensive based on how rare they are, are often ground, and move through long supply chains, making fraud harder to spot by eye.

5. How do targeted and untargeted testing differ?
   Targeted testing looks for a specific suspected adulterant. Untargeted testing builds a fingerprint of an authentic spice and flags samples that deviate—even if the exact adulterant is unknown.

6. How does near-infrared spectroscopy (NIRS) help find fake spices?
   NIRS measures how near-IR light (700-2500 nm wavelengths) is absorbed by molecular bonds; with chemometric models it can rapidly screen spices and flag samples that don't match authentic spectra.

7. Why might XRF miss some adulterants that NIRS can flag?
   XRF is less sensitive to elements with fewer electrons that are often called "light element", such as, C, H, and O. These atoms dominate organic adulterants, so purely organic fillers may not show up in XRF but can still change the NIRS fingerprint.

8. How can chromatography reveal illegal dyes in turmeric or chili powder?
   Synthetic dyes separate from natural pigments during chromatography; extra or unexpected colored bands indicate added dyes that shouldn't be present.

9. What simple tests can raise suspicion of spice fraud?
   Water-dye leach tests, the iodine test for starch fillers (blue-black color), density/float checks, and careful visual inspection (e.g., saffron thread shape, dye residue) can all provide quick clues.

10. Why is saffron often adulterated, and how can you spot fakes?
    Saffron is extremely expensive; authentic threads are trumpet-shaped with a bulged end and should not quickly stain water or fingers bright yellow when rubbed in cold water.

11. What happened in the Bangladesh turmeric case?
    Some vendors added lead(II) chromate to brighten color and add weight; isotopic evidence linked the pigment to elevated blood-lead levels, and enforcement plus education reduced exposures.

12. What's the difference between cassia and Ceylon ("true") cinnamon?
    Cassia (*C. cassia*) is darker, cheaper, and often higher in coumarin; Ceylon (*C. verum*) is lighter and more delicate. The most common cinnamon sold in the U.S. is cassia.

13. What are acceptable substitutes for vanilla, and why?
    Vanillin—the main flavor molecule in vanilla—can be synthesized and tastes similar to the natural extract's key component, making it a common, lower-cost substitute.

14. Why are handheld instruments important in the spice trade?
    Portable NIRS and XRF units allow rapid, non-destructive screening at warehouses and ports so problems are flagged before products reach consumers.

15. What's the consumer takeaway about spice safety?
    Buy from reputable sellers who test and trace supply chains, vary sources, and be cautious of unusually cheap products.

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

Additional Resources and Teaching Strategies

Additional Resources

❖ Labs and demonstrations

- ➢ AACT Lab: Candy & Leaf Chromatography
  https://teachchemistry.org/classroom-resources/candy-and-leaf-chromatography
  Description: Paper chromatography procedure, materials list, and teacher guidance (separating color mixtures).
- ➢ AACT Lab: Detecting Fats and Starches in Food
  https://teachchemistry.org/classroom-resources/detecting-fats-and-starches-in-food
  Description: Includes the classic iodine–starch test procedure and data table (blue-black positive).
- ➢ AACT Lab: Beer's Law Discovered
  https://teachchemistry.org/classroom-resources/beer-s-law-discovered
  Description: Intro Beer's Law lab using visible light absorption to connect color intensity and concentration.

❖ Lessons and lesson plans

- ➢ ACS National Chemistry Week: "The Hidden Life of Spices"
  https://www.acs.org/education/national-chemistry-week.html
  Description: ACS theme hub with spice-themed activities, safety tips, and kid-friendly reading.

❖ Projects and extension activities

- ➢ National Geographic Education: The Silk Road (Spice Trade Context)
  https://education.nationalgeographic.org/resource/silk-road/
  Description: Background on historic trade routes and commodities—including spices—for social-science connections.
- ➢ ACS/FDA Colloquium: Natural vs. Synthetic Colors
  https://www.acs.org/events/affiliated/fda-series/natural-and-synthetic-colors.html
  Description: Expert talks and resources on colorants in foods (manufacture, analysis, and safety).

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 foods with interesting spices such as oregano, turmeric, or saffron. Ask how they can know that the spices in their foods have not been adulterated. Ask why spices might be adulterated. Their initial ideas can be collected electronically via digital whiteboards or similar technology. As they read, students can find information to confirm or refute their original ideas.

- After students have read and discussed the article, ask students what they learned about the importance of testing for fraud in the spice trade. Ask them if they use any of the spices mentioned in the article, and how they might choose those spices going forward.

Chemistry Concepts and Standards

Connections to Chemistry Concepts

The following chemistry concepts are highlighted in this article:

- Mixtures
- Physical properties
- Organic chemistry
- Molecular structure

Correlations to Next Generation Science Standards

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

HS-PS1-2. Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and tradeoffs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

Disciplinary Core Ideas:

- PS1.A: Structure and properties of matter
- ETS1.B: Developing possible solutions

Crosscutting Concepts:

- Structure and function
- Cause and effect
- Energy and matter

Science and Engineering Practices:

- Asking questions and defining problems

Nature of Science:

- Science is a human endeavor.

See how *ChemMatters* correlates to the **Common Core State Standards** online.

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Demystifying Everyday Chemistry

Teacher's Guide

The Golden Spice

October 2025

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Anticipation Guide

Name: _____

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. People discovered the wound-healing properties of turmeric only recently (in the past 30 years).
		2. A pigment in turmeric produces the color in golden milk lattes.
		3. The main chemicals in turmeric (curcumin and ferulic acid) contain only carbon, hydrogen, and oxygen.
		4. Baking soda is a weak acid.
		5. Today's commercially available goldenrod colored paper changes color when treated with a base.
		6. Yellow mustard in the U. S. often has added turmeric.
		7. Curcumin easily dissolves in blood.
		8. Curcumin breaks apart in mildly basic solutions such as blood.
		9. The health benefits of turmeric have been demonstrated in numerous scientific studies.
		10. Lead chromate is similar in color to turmeric.

Student Reading Comprehension Questions

Name: _____

Directions: Use the article to answer the questions below.

1. Why was a United States patent on the oral and topical use of turmeric powder revoked?

2. How is turmeric powder obtained?

3. What are flavonoids and where are they found?

4. What limitations does curcumin, the active ingredient in turmeric, have for use as a pharmaceutical?

5. Would goldenrod paper be useful in helping to differentiate an acidic solution from a neutral solution in the laboratory? Explain.

6. a. Study the structures of curcumin shown in the article on page 12. Describe the chemistry of the two forms of the curcumin molecule.

   b. Which form of the molecule dominates in water?

7. What happens chemically to the enol form of the curcumin molecule in solutions with a pH greater than 8? How does this cause an observable color change?

8. What gives mustard its flavor? What substance gives yellow mustard its bright color? How could you change the color of yellow mustard to red?

Student Reading Comprehension Questions, cont.

Questions for Further Learning

Write your answers on another piece of paper if needed.

9. The article mentions that the turmeric plant resembles the ginger plant. Ginger plants contain compounds known as gingerol. Research the chemical structure for gingerol and draw it alongside the structure of curcumin represented in the article. Compare the two structures and identify some of the similarities and differences.

10. Research the properties of ferulic acid and the benefits of adding it to sunscreen and other skin care products.

Graphic Organizer

Name: _____

Directions: As you read, complete the graphic organizer below to describe some interesting facts about turmeric and its chemistry.

	Structures	**Properties**
Major Chemicals		
Possible Medical Uses		*Explanation*
Acid-base indicator	**Examples**	**Chemical explanation**

Summary: How does the information in the article relate to you, now or in the future? Answer in 1 or 2 sentences.

Answers to Reading Comprehension Questions & Graphic Organizer Rubric

1. Why was a United States patent on the oral and topical use of turmeric powder revoked?
   The Indian Council of Scientific and Industrial Research was able to document that the use of turmeric powder to heal wounds was well-known in Indian culture and that turmeric had been used to heal wounds for many years. Thus, the United States was not the first to make this discovery and the patent was rescinded in a landmark case in 1998.

2. How is turmeric powder obtained?
   The underground stem of the plant called the rhizome is dried and then ground to make a powder.

3. What are flavonoids and where are they found?
   Flavonoids are a group of compounds that occur in plants. They give fruits and vegetables bright colors and flavors. In addition, these compounds, including curcumin, have antioxidants that can have anti-inflammatory health benefits.

4. What limitations does curcumin, the active ingredient in turmeric, have for use as a pharmaceutical?
   Curcumin is an unstable molecule in our bodies and not bioavailable. Human blood is slightly basic, and the curcumin molecule breaks apart (hydrolyzes) in basic solution. In addition, it is not well absorbed into our bloodstream or intestines because it is not very soluble in water.

5. Would goldenrod paper be useful in helping to differentiate an acidic solution from a neutral solution in the laboratory? Explain.
   No, goldenrod paper which is made by soaking paper in a turmeric dye, turns red in basic solution, but remains gold in both neutral and acidic solution. Therefore, this test alone would not allow someone to differentiate between a neutral and acidic solution.

6. a. Study the structures of curcumin shown in the article on page 12. Describe the chemistry of the two forms of the curcumin molecule.
   Curcumin exists in equilibrium in the enol and di-keto forms. The enol form has a double bonded oxygen atom and an OH group on the carbon chain. The di-keto form has two double bonded oxygen atoms on the carbon chain.

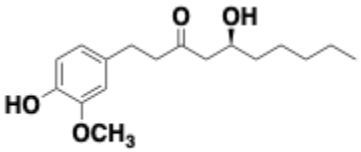
   b. Which form of the molecule dominates in water?
   The di-keto form is preferred in polar solvents like water.

7. What happens chemically to the enol form of the curcumin molecule in solutions with a pH greater than 8? How does this cause an observable color change?
   In a high pH environment, the enol form of the curcumin molecule loses three H^+ ions (it deprotonates). The change affects the energy of the electrons in the molecule such that it absorbs light of a different wavelength than its protonated form so we observe the color red.

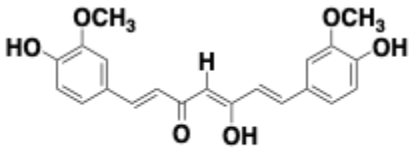
8. What gives mustard its flavor? What substance gives yellow mustard its bright color? How could you change the color of yellow mustard to red?
   Yellow mustard gets its flavor from ground seeds from the mustard plant. Turmeric is added to create the bright yellow color. To change the color to red, a base such as baking soda can be added.

Questions for Further Learning

9. The article mentions that the turmeric plant resembles the ginger plant. Ginger plants contain compounds known as gingerol. Research the chemical structure for gingerol and draw it alongside the structure of curcumin represented in the article. Compare the two structures and identify some of the similarities and differences.
   Answers will vary, but should include the fact that both gingerol and curcumin molecules have OH groups, OCH_3 groups, and an aromatic ring. Noted differences include the fact that curcumin has two rings, and alternating single and double bonds on its chain, whereas gingerol has single bonds.



Gingerol



Curcumin

10. Research the properties of ferulic acid and the benefits of adding it to sunscreen and other skin care products.
    Answers will vary, but the students should include the fact that ferulic acid boosts the effectiveness of sunscreen by neutralizing free radicals and stabilizing other ingredients to increase UV protection.

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

Additional Resources and Teaching Strategies

Additional Resources

❖ Labs and demonstrations

- ➢ Watch this video to learn about how chemists have used acid/base chemistry to make the curcumin in turmeric powder more bioavailable when used in beverages.
  https://www.youtube.com/watch?v=ZaJfhFAoEnY&t=58s
  After watching the video, try several recipes for "golden milk latte" and find your favorite!

❖ Projects and extension activities

- ➢ The Spice Sellers' Secret
  Read more about how Stanford University scientists discovered lead in turmeric.
  https://stanmed.stanford.edu/turmeric-lead-risk-detect/
- ➢ Indicators of Acids and Bases
  In this activity, students investigate litmus paper, phenolphthalein, and cabbage juice indicators to test for acidic and basic solutions. Turmeric paper could be added to this activity as an additional acid/base indicator.
  https://teachchemistry.org/classroom-resources/indicators-of-acids-and-bases

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 have heard of turmeric, and if they know what it is used for. Their initial ideas can be collected electronically via digital whiteboards or similar technology. As they read, students can find information to confirm or refute their original ideas.
- After students have read and discussed the article, ask students what they learned about turmeric and where they might have ingested it.

Chemistry Concepts and Standards

Connections to Chemistry Concepts

The following chemistry concepts are highlighted in this article:

- Acids & Bases
- Indicators
- Solutions
- Physical properties
- Molecular structure

Correlations to Next Generation Science Standards

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

HS-PS1-3. Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

Disciplinary Core Ideas:

- PS1.A: Structure and Properties of Matter
- PS1.B: Chemical Reactions

Crosscutting Concepts:

- Structure and function
- Energy and matter

Science and Engineering Practices:

- Obtaining, evaluating, and communicating information

Nature of Science:

- Science is a human endeavor.

See how *ChemMatters* correlates to the **Common Core State Standards** online.

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Teacher's Guide

Toxic Flavors

October 2025

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Anticipation Guide

Name: _____

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. It is impossible to remove all heavy metals from food.
		2. Heavy metals are most dangerous for children.
		3. Foods containing heavy metals have a metallic taste.
		4. Ingested heavy metals accumulate in the body.
		5. Organic cocoa contains less cadmium and lead than cocoa produced using conventional methods.
		6. Many foods naturally contain heavy metals.
		7. Most heavy metal exposure is natural.
		8. It is estimated that fewer than a half million people die annually from lead exposure.
		9. Eating a variety of foods means your body will absorb fewer heavy metals.
		10. Iron and calcium are heavy metals.

Student Reading Comprehension Questions

Name: _____

Directions: Use the article to answer the questions below.

1. What is bioaccumulation?
2. What is the difference between exposure and dose, and why does it matter?
3. How do plants absorb heavy metals from soil?
4. What do scientists mean by a “heavy metal,” and why can some be dangerous?
5. What does “the dose makes the poison” mean for foods?
6. Which foods were mentioned with possible metal contamination, and why?
7. How did scientists trace lead exposure to adulterated turmeric?
8. What tools can screen for metals in the field?
9. Why doesn’t an “organic” label guarantee lower metals?
10. What’s one practical way to lower risk at home?
11. How do regulators define “safe enough”?
12. Why is lead considered especially concerning?
13. What broader actions are underway to reduce exposure?
14. What’s the big-picture message for consumers?

Graphic Organizer

Name: _____

Directions: As you read, complete the graphic organizer below to describe heavy metals found in foods.

<table>
<tr><td>Why are heavy metals so harmful?</td><td colspan="3">1.
2.
3.</td></tr>
<tr><td rowspan="4">Examples of heavy metals in food</td><td>Food</td><td>Heavy metal</td><td>How heavy metal got there</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>How can heavy metals in foods be detected?</td><td colspan="3">1.
2.
3.</td></tr>
<tr><td>How can you protect yourself from consuming too much heavy metal?</td><td colspan="3"></td></tr>
</table>

Summary: On the back of this paper, write a short text to a friend describing what is meant by “The dose makes the poison” when trying to avoid consuming heavy metals.

Answers to Reading Comprehension Questions & Graphic Organizer Rubric

1. What is bioaccumulation?
   Bioaccumulation is the build-up of a substance in a living organism because the rate of intake is greater than the rate of elimination. For heavy metals like lead or cadmium that the body cannot use or clear quickly, small repeated exposures can add up to harmful levels in body tissue over time.

2. What is the difference between exposure and dose, and why does it matter?
   Exposure is contact with a contaminant in air, water, soil, or food, while dose is how much actually enters the body (often per kilogram) by eating, breathing, or skin absorption. Risk depends mainly on dose (the amount of chemical one is exposed to) and how often you receive it, not just on the fact that exposure occurred.

3. How do plants absorb heavy metals from soil?
   Plants absorb dissolved ions through their roots using transport proteins. Some heavy metals "hitchhike" by mimicking needed nutrients (for example, cadmium can follow zinc pathways), and factors like soil pH, organic matter, and chelating compounds change how available those metals are, with some plant species (hyper-accumulators) moving more metal into edible parts.

4. What do scientists mean by a "heavy metal," and why can some be dangerous?
   Heavy metals, like lead, cadmium, mercury, have relatively high atomic masses and can bind to enzymes and DNA; many bioaccumulate, so repeated small exposures can add up and harm organs and the brain.

5. What does "the dose makes the poison" mean for foods?
   Risk depends on how much and how often you're exposed; tiny amounts may be natural, while sustained intake above health-based guidelines raises concern.

6. Which foods were mentioned with possible metal contamination, and why?
   Some spices, rice, cocoa/chocolate, and certain fish can contain trace metals from soil, water, processing, or—rarely—adulteration.

7. How did scientists trace lead exposure to adulterated turmeric?
   By matching lead isotope ratios in blood, turmeric, and pigments to lead(II) chromate added for color, confirming the source and guiding enforcement.

8. What tools can screen for metals in the field?
   Handheld XRF can quickly detect elements without destroying samples; newer photoluminescent reagents can glow under UV in the presence of trace lead on surfaces.

9. Why doesn't an "organic" label guarantee lower metals?
   Organic rules limit certain pesticides and fertilizers but don't change geologic metals in soil or contamination during transport or processing.

10. What's one practical way to lower risk at home?
    Eat a varied diet, buy from trusted sources, and ensure adequate iron and calcium intake, which can reduce the body's absorption of lead.

11. How do regulators define "safe enough"?
    Agencies analyze data to set reference doses or action levels; occasional exceedances don't equal poisoning—long-term averages matter most.

12. Why is lead considered especially concerning?
    There is no known safe level for lead exposure, and even low levels can affect learning and behavior in children.

13. What broader actions are underway to reduce exposure?
    Efforts include removing lead sources, improving testing and surveillance, enforcing against adulteration, and supporting global initiatives to end childhood lead poisoning.

14. What's the big-picture message for consumers?
    Be informed but not fearful: metals can be present at trace levels, but simple habits—variety, balanced diet, reputable brands—reduce risk.

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.
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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

Additional Resources and Teaching Strategies

Additional Resources

❖ Labs and demonstrations

- ➢ AACT Lab: The Gravimetric Analysis of Lead in Contaminated Water
  https://teachchemistry.org/classroom-resources/the-gravimetric-analysis-of-lead-in-contaminated-water
  Description: HS lab using precipitation and stoichiometry to quantify simulated "lead" in water; includes materials, procedure, and analysis.

❖ Projects and extension activities

- ➢ ACS ChemMatters: The Flint Water Crisis (PDF)
  https://www.acs.org/content/dam/acsorg/education/resources/highschool/chemmatters/issues/2016-2017/December%202016/chemmatters-dec2016-flint-water-crisis.pdf
  Description: Feature article explaining corrosion control, pipe chemistry, and how lead leaches into drinking water.
- ➢ WHO Fact Sheet: Lead Poisoning and Health
  https://www.who.int/news-room/fact-sheets/detail/lead-poisoning-and-health
  Description: Clear, student-friendly background on sources, health effects, and global prevention strategies.
- ➢ CDC: Know the Facts — Protect Your Child from Lead
  https://www.cdc.gov/lead-prevention/communication-resources/know-the-facts.html
  Description: Concise guidance and quick facts; helpful for risk-communication or public-health tie-ins.
- ➢ National Geographic: This is what you need to know about lead and your health
  https://www.nationalgeographic.com/science/article/lead-history-health-risks-impacts
  Description: Overview of health impacts, exposure sources, and prevention; useful context for classroom discussion.

Teaching Strategies

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

- **Alternative to Anticipation Guide:** Before reading, ask students how they know their food is safe to eat. Ask them what dangerous elements might be in their food, and how they get there. Their initial ideas can be collected electronically via digital whiteboards or similar technology. As they read, students can find information to confirm or refute their original ideas.
- After students have read and discussed the article, ask students what they learned about how they can reduce heavy metal consumption, and why it's important.

Chemistry Concepts and Standards

Connections to Chemistry Concepts

The following chemistry concepts are highlighted in this article:

- Elements
- Metals
- Physical properties
- Chemical properties
- Environmental chemistry

Correlations to Next Generation Science Standards

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

HS-PS1-1. Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.

Disciplinary Core Ideas:

- PS1.A: Structure and properties of matter

Crosscutting Concepts:

- Patterns
- Cause and effect
- Scale, proportion, and quantity

Science and Engineering Practices:

- Analyzing and interpreting data

Nature of Science:

- Science knowledge assumes an order and consistency in natural systems.

See how *ChemMatters* correlates to the **Common Core State Standards** online.

ChemMatters®
Demystifying Everyday Chemistry

Teacher's Guide

Some Like It Hot

October 2025

Table of Contents

Anticipation Guide

Name: _____

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. Only about one-tenth of the world's population enjoy hot peppers daily.
		2. Chiles originally came from Africa.
		3. Chile peppers have antibacterial and antifungal properties.
		4. The heat in a pepper is measured in Scoville Heat Units (SHUs), which began as a subjective linear scale using professional tasters.
		5. The heat of peppers is affected by the soil type and temperatures.
		6. Capsaicin, the chemical responsible for the heat in peppers, dissolves in water.
		7. Capsaicin is concentrated in the tissues around plant seeds.
		8. Capsaicin has been weaponized.
		9. Capsaicin has no health benefits.
		10. Birds do not taste capsaicin.

Student Reading Comprehension Questions

Name: _____

Directions: Use the article to answer the questions below.

1. Why do hotter countries use spices in their foods more than countries with cooler climates?

2. Briefly explain how capsaicin causes the body to feel pain or a burning sensation.

3. Describe how the Scovill scale is determined.

4. What is the difference between the hydrophilic and hydrophobic?

5. List a few other uses for chili powder that are not for food flavor.

6. How does milk casein assist in relieving the pain from capsaicin?

7. Explain how important birds are for chili peppers to continue to spread and multiply. Why cannot mammals do the same?

8. Describe the importance of both the hydrophilic and hydrophobic ends of a soap molecule.

9. Explain the similarities of soap and milk when it comes to dissolving capsaicin.

10. How do you think the Scovill scale would be different if it were developed by someone who lived in a milder climate.

Student Reading Comprehension Questions, cont.

Questions for Further Learning

Write your answers on another piece of paper if needed.

11. A common phrase for mixing substances is: “like dissolves like”. Using the info from this article regarding dissolving capsaicin, as well as the concepts of polar and non-polar molecules, explain this phrase.

Graphic Organizer

Name: _____

Directions: As you read, complete the graphic organizer below to describe hot chile peppers and capsaicin.

Where are they grown?		
What cultures use them in food?		
What affects amount of capsaicin in peppers?		
Effects of capsaicin on body		
Possible health benefits		
Possible harms		
How to get relief from capsaicin		*Why does it work?*
Advantage of capsaicin to plants		

Summary: On the back of this paper, write a short text to a friend who enjoys hot peppers summarizing what you learned from the article.

Answers to Reading Comprehension Questions & Graphic Organizer Rubric

1. Why do hotter countries use spices in their foods more than countries with cooler climates?
   The spices have antibacterial and antifungal properties, so the people use these spices to preserve the food.

2. Briefly explain how capsaicin causes the body to feel pain or a burning sensation.
   The capsaicin triggers pain receptors and tricks them into thinking there is a temperature change, and the body feels a sensation of heat.

3. Describe how the Scovill scale is determined.
   The scale was developed in 1912, and it represents how much the chili extract needs to be diluted in sugar water until the heat is not noticeable.

4. What is the difference between the hydrophilic and hydrophobic?
   Hydrophilic means the substance is attracted to water (and is polar). Hydrophobic means the substance will repel water (and is nonpolar).

5. List a few other uses for chili powder that are not for food flavor.
   Powdered ghost peppers were used as an elephant repellant, and the Mayans burned chili peppers to produce painful smoke to irritate their enemies. Chili powder is also used in pepper sprays. Scientists are also experimenting using chili powder as pain relief.

6. How does milk casein assist in relieving the pain from capsaicin?
   The casein in milk is attracted to the capsaicin. It will surround the capsaicin molecule and remove it from the pain receptors in the body.

7. Explain how important birds are for chili peppers to continue to spread and multiply. Why cannot mammals do the same?
   Animals are needed to carry the seeds of plants to different areas, so the plants can continue to grow and thrive. A bird's digestive system cannot break down the chili seeds, so they can deposit these seeds in different areas. Mammals, however, cannot do this because their stomach acid is too strong and will break down the seeds.

8. Describe the importance of both the hydrophilic and hydrophobic ends of a soap molecule.
   The hydrophobic end of a soap molecule resists water, but its structure and nonpolar properties will attract and attach to the dirt and other impurities. The hydrophilic ends will attach to the water

molecules and when they are washed away with the water, the hydrophobic ends take the dirt/impurities with it.

9. Explain the similarities of soap and milk when it comes to dissolving capsaicin.
   Both milk and soap contain fats which are nonpolar and attract the nonpolar capsaicin molecule. This pulls the molecule away from the pain receptors. Milk fats are called triglycerides, which contain three fatty acids connected by a glycerol molecule. Soap, which is made through the process called saponification, is made when triglycerides are broken down into the fatty acids and glycerol. The fatty acids form micelles—a spherical structure with a hollow core—with polar water loving ends on the outside of the sphere, and nonpolar water hating ends on the inside of the sphere. Nonpolar molecules like capsaicin are caught up by the nonpolar ends and encapsulated in the center of the micelle. The polar outside ends get washed away with the water.

10. How do you think the Scovill scale would be different if it were developed by someone who lived in a milder climate.
    Since the Scovill scale is based on taste tests, the levels are subject to the tolerance of spicy foods on the taster. If the developer was from a cooler, milder climate, or someone who does not eat as much spicy food, then the scale would be developed differently. Most of the Scovill levels would probably be lower than what they are now. The Scovill scale is a subjective test, meaning that personal preferences, experience and even location influence the scores.

Questions for Further Learning

11. A common phrase for mixing substances is: “like dissolves like”. Using the info from this article regarding dissolving capsaicin, as well as the concepts of polar and non-polar molecules, explain this phrase.
    Some substances will mix easily with other substances, and some will not mix at all. This is based on the structures of the molecules. Some molecules are polar (have a negatively charged end and a positively charged end). If two different substances are polar, they will mix (for example, alcohol and water). If one of the substances is polar, and the other is not polar, they will not mix (for example, water and oil).

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

Additional Resources and Teaching Strategies

Additional Resources

❖ Labs and demonstrations

- ➢ Lab: https://teachchemistry.org/classroom-resources/solubility-and-compound-type
- ➢ Lab: https://teachchemistry.org/classroom-resources/magic-milk

❖ Lessons and lesson plans

- ➢ Lesson Plan: https://teachchemistry.org/classroom-resources/making-sense-of-milk

❖ Projects and extension activities

- ➢ Animation: https://teachchemistry.org/classroom-resources/solubility-animation
- ➢ Video: The Science of Spiciness The science of spiciness - Rose Eveleth

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 eating hot peppers. Ask what effects eating hot peppers has on the body. Consider engaging students by showing this PBS NOVA video: "Why Hot Peppers Set Your Mouth on Fire" (4:02). Their initial ideas can be collected electronically via digital whiteboards or similar technology. As they read, students can find information to confirm or refute their original ideas.
- After reading, the ACS Reactions video "Why Do Hot Peppers Cause Pain?"(4:27) would be a good review for the information in the article.
- After students have read and discussed the article, ask students what they learned about hot peppers, and whether the information will affect their future decisions about eating hot peppers.

Chemistry Concepts and Standards

Connections to Chemistry Concepts

The following chemistry concepts are highlighted in this article:

- Solubility
- Molecular structure

Correlations to Next Generation Science Standards

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

HS-LS1-3. Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.

Disciplinary Core Ideas:

- LS1.A: Structure and Function
- PS1.A: Structure and Properties of Matter

Crosscutting Concepts:

- Cause and effect
- Structure and function

Science and Engineering Practices:

- Obtaining, evaluating, and communicating information

Nature of Science:

- Science addresses questions about the natural and material world.

See how *ChemMatters* correlates to the **Common Core State Standards** online.