ChemMatters®
Demystifying Everyday Chemistry

Teacher's Guide

December 2025

www.acs.org/chemmatters

December Teacher's Guide Introduction

The December 2025 issue of *ChemMatters* provides engaging information about current societal concerns, including the use of seed oils, ethics of coffee production, and wastewater surveillance. These articles will help students understand how we know what we know using scientific methods of understanding. Most of the articles clearly link claims and evidence using scientific reasoning. Students might also think about how a scientific career might be appealing to them since most articles feature real scientists who clearly enjoy what they do. 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.

Teaching Ideas for this issue:

1. "Open for Discussion" on pages 3 and 4 includes information about banning synthetic food dyes. Ask students if they have ever thought about how their foods are colored, and whether it matters to them. After they read the article, ask if the information will affect their food choices and why.

2. "Quick Read: Molecular Organic Frameworks" on page 18 describes the chemistry of the material for which three people won the 2025 Nobel Prize in Chemistry. Ask students why they think the Nobel committee awarded their research, and how the MOF materials might be used in the future.

3. "Nano Reads" on page 19 summarizes 4 different areas of interesting recent research related to chemistry. You might ask students which topic interests them most, and why.

4. The "Chemistry in Person" column on page 23 is an interview with someone who was awarded the Nobel Prize for Chemistry in 2020, including what she has done since winning the Nobel Prize. Ask students to describe her career, including the work for which she was awarded the Nobel Prize, and her advice for students.

5. Most of the articles would be very useful for using the Claims, Evidence Reasoning (CER) format to understand the work of scientists. If you are not familiar with the CER framework, here is a short article describing how to help students use the format to write explanations: https://www.edutopia.org/blog/science-inquiry-claim-evidence-reasoning-eric-brunsell

6. Consider assigning a team of students to read one if the feature articles, then present what they learned in a podcast, PowerPoint or similar presentation, poster or brochure, or some other engaging format.
    a. Prior to reading the article, give students the Anticipation Guide for the article along with the graphic organizer and links to other information provided.
    b. Be sure to ask students to include information providing evidence for the claims made in the article.

7. Alternatively, students can create concept maps about the important chemistry concepts in the feature 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…

ChemMatters®
Demystifying Everyday Chemistry

Teacher's Guide

Seed Oils

December 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. A healthy diet should include no more than 10% of calories from fats.
		2. Vitamins A, D, E and K are fat soluble.
		3. Butter is an unsaturated fat.
		4. Both observational trials and clinical trials are scientific.
		5. Saturated fats have only single bonds in the carbon chain.
		6. The evidence is clear that saturated fats lower the risk of cardiovascular disease.
		7. All fats contain nine calories per gram.
		8. In the United States, ingredients must be proven safe before they are allowed in the food supply.
		9. Clinical trials show that linoleic acids increase inflammation in humans.
		10. Peanut oil is more stable than most other oils.

Student Reading Comprehension Questions

Name: _____

Directions: Use the article to answer the questions below.

1. What makes a molecule a “fat”?
2. What does it mean for a fat to be “unsaturated”?
3. What is meant by “omega-6” or “omega-3” fatty acids?
4. How are seed oils extracted from plants?
5. How does “like dissolves like” apply to seed oils and water?
6. What happens when an oil is heated during frying?
7. Why are some oils labeled “high-oleic”?
8. What is oxidation, and why does it matter in frying?
9. How does hydrogenation change an oil?
10. Why do double bonds make oils healthier but less stable?
11. What role does polarity play in the health debate?
12. How can reactivity be mistaken for toxicity?
13. Why does heat or light speed up oil spoilage?
14. What does “refining” mean in chemistry terms?
15. How does chemistry help you evaluate online claims about food?

Graphic Organizer

Name: _____

Directions: As you read, complete the graphic organizer below to analyze claims made about seed oils.

Claim & Description	Evidence	Scientific Reasoning
#1		
#2		
#3		
#4		

Summary: Write a one-sentence summary (18 words or less) of the article about the importance of linking claims and evidence to help make informed decisions.

Answers to Reading Comprehension Questions & Graphic Organizer Rubric

1. What makes a molecule a “fat”?
   Fats and oils are made of triglycerides—molecules built from glycerol and three fatty acids. These long hydrocarbon chains store chemical energy in carbon–hydrogen bonds. The difference between a fat and an oil is primarily physical: fats are solid at room temperature, oils are liquid, but chemically they are the same class of compounds.

2. What does it mean for a fat to be “unsaturated”?
   Unsaturated fats contain one or more carbon–carbon double bonds (C=C). These double bonds bend the chain and prevent molecules from packing tightly, keeping the substance liquid. Saturated fats, with only single bonds, have straight chains and form solids like butter.

3. What is meant by “omega-6” or “omega-3” fatty acids?
   The term describes the position of the first double bond counting from the methyl (CH_3) end of the fatty acid. Omega-6 means the first C=C occurs at the sixth carbon; omega-3 means it occurs at the third. The location of these bonds changes how the molecule folds and reacts.

4. How are seed oils extracted from plants?
   Most commercial producers crush the seeds and use a nonpolar solvent such as hexane to dissolve the oil (“like dissolves like”). After extraction, the solvent is removed by evaporation and refining steps. Only trace amounts—well below safety limits—remain.

5. How does “like dissolves like” apply to seed oils and water?
   Triglycerides are largely nonpolar hydrocarbons, so they dissolve readily in nonpolar solvents. Water, which is polar, does not mix with oil because their intermolecular forces are incompatible.

6. What happens when an oil is heated during frying?
   Heat provides energy that can break or rearrange chemical bonds. Unsaturated fats oxidize at double bonds, producing aldehydes, ketones, and small organic acids. Reusing oil accelerates this because oxygen and leftover food particles act as catalysts.

7. Why are some oils labeled “high-oleic”?
   These oils have been bred or processed to contain more oleic acid (a monounsaturated fat) and fewer polyunsaturated chains. Fewer double bonds mean fewer reactive sites for oxidation, so the oil lasts longer under heat.

8. What is oxidation, and why does it matter in frying?
   Oxidation is the reaction of oxygen with double bonds, forming peroxides and other unstable compounds. These intermediates can decompose into molecules that affect flavor and safety. Antioxidants like vitamin E slow the reaction.

9. How does hydrogenation change an oil?
   Hydrogenation adds hydrogen atoms to double bonds, converting unsaturated to saturated bonds. Partial hydrogenation can also create trans fats, where the double bond remains but the molecule straightens, raising melting point and changing biological effects.

10. Why do double bonds make oils healthier but less stable?
    Chemically, double bonds make molecules more reactive (less stable), yet physiologically they're beneficial because the body uses them to synthesize cell membranes and signaling molecules.

11. What role does polarity play in the health debate?
    Many misconceptions treat all "chemicals" as harmful. Understanding polarity shows why residues or oxidation products behave differently: nonpolar molecules don't dissolve easily in water and are metabolized slowly, not necessarily toxically.

12. How can reactivity be mistaken for toxicity?
    Reactivity describes how readily a molecule participates in chemical reactions; toxicity describes how harmful it is biologically. Unsaturated fats are reactive but not inherently dangerous—context and dose determine health effects.

13. Why does heat or light speed up oil spoilage?
    Energy from heat or UV light can break C–H bonds and initiate radical reactions that oxidize unsaturated chains. That's why oils are stored in dark, airtight bottles.

14. What does "refining" mean in chemistry terms?
    Refining removes free fatty acids, pigments, and other polar impurities using neutralization and filtration. Each step uses differences in chemical polarity and volatility to purify the product.

15. How does chemistry help you evaluate online claims about food?
    By applying molecular reasoning—structure, bonding, and reaction pathways—you can test whether a claim makes sense. If someone says a compound is "toxic," chemistry helps you ask how much, under what conditions, and why.

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

AACT (American Association of Chemistry Teachers) – Labs & Classroom Resources

- Oil and Water Don't Mix (polarity & intermolecular forces) https://teachchemistry.org/classroom-resources/oil-and-water-dont-mix (AACT)
- Salad Dressing Science: Emulsions (emulsifiers, polarity, phase behavior) https://teachchemistry.org/classroom-resources/salad-dressing-science-emulsions (AACT)
- Designing Biomimetic Songbird Preen Oil from Waste Cooking Oil (reaction of lipids → methyl ketones; oxidation/antibacterial context) https://teachchemistry.org/classroom-resources/designing-biomimetic-songbird-preen-oil-from-waste-cooking-oil(AACT)
- Food Chemistry Topic Collection (browse additional oil/fat activities) https://teachchemistry.org/classroom-resources/topics/food-chemistry (AACT)

ACS (American Chemical Society) – Education & Media

- ACS Chemistry in Context – Nutrition interactives (hydrogenation simulator, fatty-acid models) https://www.acs.org/education/resources/undergraduate/chemistryincontext/interactives/nutrition.html (American Chemical Society)
- ACS Reactions – Agriculture & Food topic page (curated food-chem videos; useful for oxidation, fats, kitchen chemistry) https://www.acs.org/pressroom/reactions/topics/agriculture-food.html (American Chemical Society)

Background Reading (general science, accessible)

- Harvard T.H. Chan – The Nutrition Source: Fats & Cholesterol https://nutritionsource.hsph.harvard.edu/what-should-you-eat/fats-and-cholesterol/ (The Nutrition Source)
- Harvard Health – Seeding doubt: The truth about cooking oils (hexane extraction note; plain-language overview) https://www.health.harvard.edu/heart-health/seeding-doubt-the-truth-about-cooking-oils (Harvard Health)
- Science Focus – Why animal fats are solid and vegetable oils liquid (structure–property link) https://www.sciencefocus.com/science/why-are-animal-fats-solid-yet-vegetable-oils-liquid-at-room-temperature(Science Focus)

Teaching Strategies

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

- **Alternative to Anticipation Guide:** Before reading, ask for examples of seed oils, and why they are often used in cooking instead of butter or lard. Ask how our use of seed oils has changed over time. Ask if they know the differences between saturated and unsaturated fats, and which has been linked to a risk of heart disease. 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 seed oils and whether they will use them in the future.

Chemistry Concepts and Standards

Connections to Chemistry Concepts

The following chemistry concepts are highlighted in this article:

- Scientific method
- Biochemistry
- Macronutrients
- Molecular structure
- Saturated vs. unsaturated

Correlations to Next Generation Science Standards

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

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.A: Defining and delimiting engineering problems
- ETS1.B: Developing possible solutions

Crosscutting Concepts:

- Cause and effect
- Structure and function
- Stability and change

Science and Engineering Practices:

- Analyzing and interpreting data
- Engaging in argument from evidence
- Obtaining, evaluating, and communicating information

Nature of Science:

- Scientific knowledge is based on empirical evidence.

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

ChemMatters®
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Teacher's Guide

Kopi Luwak

December 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. Coffee beans are seeds from red coffee cherries.
		2. Luwaks are civets found in Indonesia.
		3. The most dominant species of coffee is *Coffea liberica*.
		4. Eating coffee beans collected from civet scat is safe for humans.
		5. Wild civets eat only coffee fruit.
		6. Researchers have used a scanning electron microscope to find if molecules of kopi luwak are authentic.
		7. During the coffee roasting process, amino acids react with sugars.
		8. Civets seem to prefer *Coffea arabica* beans.
		9. Caffeine levels among beans of the same species are the same.
		10. Scientists are working to develop coffee with a similar taste to kopi luwak in the lab.

Student Reading Comprehension Questions

Name: _____

Directions: Use the article to answer the questions below.

1. Does the word luwak refer to an Asian plant or a cat? Explain.

2. Explain how coffee beans can take a detour through an animal.

3. Explain the history behind the spread of kopi luwak.

4. Is it safe to drink kopi luwak? Explain.

5. Why is kopi luwak sometimes referred to as the "world's most expensive coffee"?

6. What ethical issue surrounds kopi luwak?

   b. How might people produce economically desirable kopi luwak in a responsible way?

7. What differences between the sample and control beans did Marcone find when he performed his analysis?

   b. What was the importance of using a control sample in the analysis?

8. What are some additional variables that might account for differences in coffee samples.

Questions for Further Learning

9. The article mentions that some scientists analyze coffee beans using a scanning electron microscope (SEM). Research how this important piece of analytical equipment works.

10. Research the chemical analysis of kopi luwak to learn more about the unique properties of this coffee.

Graphic Organizer

Name: _____

Directions: As you read, complete the graphic organizer below to describe how scientists are working to determine why kopi luwak is so special.

	Kopi luwak	Other coffee	Possible explanation for difference(s)
Microbes			
Scanning electron microscope			
Proteins			
Caffeine			
Coffee species			
Price			

Summary: On the back of this paper, write a one-sentence summary (18 words or less) of the article to share with a coffee-loving friend.

Answers to Reading Comprehension Questions & Graphic Organizer Rubric

1. Does the word *luwak* refer to an Asian plant or a cat? Explain.
   The Indonesian word luwak stands for a small nocturnal cat called the Asian palm civet. Even though the name might sound like a plant, it is a cat that lives in Southeast Asia.

2. Explain how coffee beans can take a detour through an animal.
   The fruit of a coffee plant is a cherry. Civets, bats, and elephants eat the cherries and excrete the entire coffee bean (seed) because they are unable to digest them. Kopi luwak comes from the civet's excreted coffee beans.

3. Explain the history behind the spread of kopi luwak.
   Dutch colonists in the 17th century forbade the native Indonesians from using the coffee beans they harvested in the plantations. Workers found an alternative coffee source by collecting beans from civet excrement. The Dutch eventually brought kopi luwak back to Europe.

4. Is it safe to drink kopi luwak? Explain.
   Yes, harvested coffee beans are washed and dried in processing. Roasting the beans and the heat from brewing coffee kill any microbes that might be present.

5. Why is kopi luwak sometimes referred to as the "world's most expensive coffee"?
   Kopi luwak can sell for $500 per kilogram. It is rare because it must be obtained by searching the jungle and hand-harvesting the excreted coffee beans from the civet.

6. What ethical issue surrounds kopi luwak?
   Civets are sometimes kept in cages and fed coffee fruit to produce kopi lowak in a controlled setting. This can compromise the health of the animals in an attempt to make it easier to collect the excreted beans. In addition, this practice is detrimental to the environment, because civets help contribute to the health of the jungles by acting as seed dispersers.

   b. How might people produce economically desirable kopi luwak in a responsible way?
   Some Indonesians are replacing their rubber plantations with coffee plants that civets can consume in an authentic way, rather than being kept in cages.

7. What differences between the sample and control beans did Marcone find when he performed his analysis?

   Marcone found several differences between the sample and control beans when he analyzed them. At high magnification, he observed “pits and channels” on the civet beans that he did not see on the control beans. In addition, he observed a significant difference in the proteins found in the two bean samples. Finally, he determined the two types of beans had different chemical profiles.

   b. What was the importance of using a control sample in the analysis?

   Using a control sample that did not come from a civet is critical in being able to identify similarities and differences.

8. What are some additional variables that might account for differences in coffee samples.

   Differences between coffee samples might be due to the specific coffee plant that the civet consumes. Also, caffeine levels vary from one plant to another. Finally, varying temperatures when roasting and brewing coffee can affect its molecular profile.

Questions for Further Learning

9. The article mentions that some scientists analyze coffee beans using a scanning electron microscope (SEM). Research how this important piece of analytical equipment works.

   Answers will vary, but include the idea that scanning electron microscopes have much higher resolution than an optical microscope. Electron beams are used to scan the sample. This causes electrons to be ejected, resulting in a high-resolution image of the surface of the sample. Because scanning electron microscopes are so sensitive, the sample chamber must be evacuated of all air to avoid interference from other molecules.

10. Research the chemical analysis of kopi luwak to learn more about the unique properties of this coffee.

    Answers will vary but some analysis shows that kopi luwak have higher fat content, but less caffeine and acid than other coffee varieties. These differences create a unique flavor profile.

    Source:
    https://arstechnica.com/science/2025/10/fermentation-is-key-to-coffee-beans-gleaned-from-civet-feces/

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

Article:
The Disturbing Secret Behind the World's Most Expensive Coffee
Read more about the animal welfare concerns associated with producing kopi luwak.
https://www.nationalgeographic.com/animals/article/160429-kopi-luwak-captive-civet-coffee-Indonesia#:~:text=From%20the%20size%20and%20sanitation,disturbing%20for%20these%20nocturnal%20animals

Video:
Watch this video to learn more about how the scanning electron microscope differs from the microscopes you use in school. You've never seen a penny this close!
https://www.youtube.com/watch?v=tAhovMMRcEM

Activity:
Coffee Chemistry
In this activity, students examine an infographic about two common types of coffee beans, Arabica and Robusta. Have students work in small groups to study the infographic and then research the different chemical compounds present in the different types of beans.
https://www.compoundchem.com/2018/09/30/arabica-robusta/

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 drinking coffee. Ask where coffee comes from, and what coffee drinkers might look for when choosing a coffee. Ask if they have ever heard of civet coffee (kopi luwak). 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 coffee and coffee processing, and whether the information will affect their future decisions about choosing coffee.

Chemistry Concepts and Standards

Connections to Chemistry Concepts

The following chemistry concepts are highlighted in this article:

- Scientific method
- Protein
- Amino acid
- Instrumentation

Correlations to Next Generation Science Standards

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

HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.

Disciplinary Core Ideas:

- LS1.A: Structure and Function
- LS2.A: Interdependent Relationships in Ecosystems
- PS1.A: Structure and Properties of Matter

Crosscutting Concepts:

- Cause and effect
- Structure and function

Science and Engineering Practices:

- Planning and carrying out investigations
- Analyzing and interpreting data

Nature of Science:

- Science addresses questions about the natural and material world.

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

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Teacher's Guide

Laxatives

December 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. More than 25% of the population suffers from constipation.
		2. The digestion process begins in the stomach.
		3. Proteins break down more easily in the stomach than carbohydrates.
		4. Digested food spends about 36 hours in the colon.
		5. Drinking water and physical activity can help relieve constipation.
		6. Both soluble and insoluble fiber pick up water in the trip through your digestive tract.
		7. Metamucil can relieve both constipation and mild diarrhea.
		8. Osmotic laxatives draw water into the colon.
		9. Prunes have a laxative effect because of sorbitol, a common sweetener.
		10. Lactose intolerance often causes constipation.

Student Reading Comprehension Questions

Name: _____

Directions: Use the article to answer the questions below.

1. What is an enzyme?

2. What is the main role of hydrochloric acid in the stomach?

3. Why is fiber good to have in your diet?

4. How is the acidity neutralized in the small intestine during digestion?

5. Describe a few ways to avoid constipation.

6. Describe the difference between active and passive transport.

7. What is lactose and what causes a person to be lactose intolerant. What are the consequences of being lactose intolerant? How prevalent is lactose intolerance?

8. How can you tell the difference between a solution and a colloid? Provide an example of each.

9. In osmosis, why do you think water flows from the less concentrated area to the more concentrated area?

10. If food is too difficult to digest, an excess amount of stomach acid is produced. What is the name of the feeling a person has when this happens? What do people do or take to counteract this?

Questions for Further Learning

11. Briefly describe and compare the two different types of laxatives: bulk (like Metamucil) and osmotic (MiraLAX).

Graphic Organizer

Name: _____

Directions: As you read, complete the graphic organizer below to describe the digestive process and how laxatives might help aid digestion.

Process	Importance and description	Chemicals involved
Digestion		
Nutrient uptake		
Stool formation		
Osmosis		
Lactose intolerance		

Summary: On the back of this paper, write three new things you learned about the digestive process, and explain why you chose each.

Answers to Reading Comprehension Questions & Graphic Organizer Rubric

1. What is an enzyme?
   An enzyme is a type of catalyst, which is something that speeds up a reaction by reducing the energy required to start the reaction called the activation energy.

2. What is the main role of hydrochloric acid in the stomach?
   The acid is released into the stomach to lower the pH, which is needed to unravel (denature) the protein molecules so the enzymes can break them down in digestion.

3. Why is fiber good to have in your diet?
   Fiber absorbs water, which makes stool soft, thus preventing constipation.

4. How is the acidity neutralized in the small intestine during digestion?
   The acid is neutralized by the basic bicarbonate ion (HCO_3^{1-}), which increases the low pH up to about 7.5, which is slightly basic.

5. Describe a few ways to avoid constipation.
   Drink water or other fluids, try not to hold in your bowel movements, eat more fiber, and try to avoid stress.

6. Describe the difference between active and passive transport.
   Passive transport is when molecules and ions move from a high concentration area to a low concentration area. This requires very little energy to make happen. Active transport requires more energy because the molecules and ions have to be forced to move from lower concentration to higher concentration.

7. What is lactose and what causes a person to be lactose intolerant. What are the consequences of being lactose intolerant? How prevalent is lactose intolerance?
   Lactose is the sugar present in dairy products. A person is lactose intolerant when he or she is missing the lactase enzyme, which breaks down the lactose in dairy products. Lactose intolerance can cause bloating, loose stools and incontinence issues in a person with lactose intolerance. Approximately 65% of the world's population suffers from lactose intolerance with Africans, Native Americans, Asians and Hispanic/Latinos ethnic and racial groups having the highest number of people impacted. In the United States about 36% of the population has lactose intolerance.

8. How can you tell the difference between a solution and a colloid? Provide an example of each.
   A solution is when the solute particles are broken down to the molecular level and are distributed evenly throughout the solvent. You cannot typically see the solute particles in solution. A colloid happens when smaller, lighter particles are "suspended" in the medium, which contain larger particles. You should be able to see the suspended particles. Well water is an example of a solution, there are dissolved minerals and salts in well water; whereas salad dressing is a good example of a colloid where herbs and pepper may be suspended in the liquid base of the dressing.

9. In osmosis, why do you think water flows from the less concentrated area to the more concentrated area?
   Water will flow from the less concentrated area to the more concentrated area until both sides have equal concentration.

10. If food is too difficult to digest, an excess amount of stomach acid is produced. What is the name of the feeling a person has when this happens? What do people do or take to counteract this?
    This is called acid reflux, or heartburn. Typically, people will take an antacid, which contains a base which will neutralize the excess acid.

Questions for Further Learning

11. Briefly describe and compare the two different types of laxatives: bulk (like Metamucil) and osmotic (MiraLAX).
    Bulk laxatives contain large amounts of fiber. The main ingredient of metamucil is a seed husk that is polar, which helps attract water to the stool. Osmotic laxatives do not digest in the stomach or intestine, but they create a higher solute concentration, which causes more water to flow through the walls of the colon, softening the stool.

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

Infographic
Compound Chemistry: Laxatives-and-antidiarrheals
https://www.compoundchem.com/wp-content/uploads/2024/07/Laxatives-and-antidiarrhoeals.pdf

Demonstration
Osmosis Demonstration: Soft Eggs
https://teachchemistry.org/classroom-resources/soft-eggs

Lesson Plan
Diffusion and Osmosis
https://teachchemistry.org/classroom-resources/diffusion-and-osmosis

Demonstration
Milk of Magnesia Magic
https://teachchemistry.org/classroom-resources/milk-of-magnesia-magic

Teaching Strategies

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

- **Alternative to Anticipation Guide:** Before reading, ask students to describe the digestive process. Ask why someone might consider taking a laxative and how they work. 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 digestive process and how laxatives work.

Chemistry Concepts and Standards

Connections to Chemistry Concepts

The following chemistry concepts are highlighted in this article:

- Physical change
- Chemical change
- Osmosis
- Solubility
- pH

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:

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

Crosscutting Concepts:

- Structure and function
- Cause and effect
- Systems and system models

Science and Engineering Practices:

- Constructing explanations and designing solutions

Nature of Science:

- Science models, laws, mechanisms, and theories explain natural phenomena.

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

ChemMatters®
Demystifying Everyday Chemistry

Teacher's Guide

Sewers

December 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. COVID-19 can be detected in wastewater only if people are symptomatic with the virus.
		2. Wastewater surveillance can detect viruses as well as bacteria from infected people.
		3. Tracking disease using wastewater surveillance has only been used since the early 2000s.
		4. When a wastewater sample is brought to the lab, it is inactivated with ultraviolet light or heat.
		5. Viruses are identified using DNA and RNA.
		6. Interpreting the data from wastewater samples is straightforward.
		7. Wastewater from airports and airplanes is not surveilled.
		8. DNA is 99.9% the same for every human being.
		9. Currently there is a global network of aircraft-based surveillance sites to provide an early-warning system for emerging pathogens.
		10. Wastewater from septic systems is routinely monitored.

Student Reading Comprehension Questions

Name: _____

Directions: Use the article to answer the questions below.

1. Who was the first person to track diseases through a population? When did this happen? What was the disease?

2. State 2-3 other times in the past diseases were tracked. Include the years and the diseases that were tracked.

3. Briefly explain how scientists safely neutralize and prep wastewater before they analyze it.

4. Explain another way wastewater tracking is used, other than sewers or water treatment plants.

5. How similar is the DNA of humans?

6. Why did scientists need to find a way to make more of the DNA of the diseases they are studying?

7. What is the process to replicate DNA called? How does this work?

8. Why is it harder to track diseases in rural areas of the country?

9. What could be some other uses for PCR?

10. What could be some possible issues that could be problematic for wastewater testing?

Questions for Further Learning

11. Suppose you were told that the wastewater from your school will be tested for one or more suspected diseases that may be spread. What would the pros and cons be? How would you feel about this happening? What do you think the school should do if the tests showed that a communicable disease was possibly carried by one of the members of your school?

Graphic Organizer

Name: _____

Directions: As you read, complete the graphic organizer below to describe how wastewater surveillance has changed over time.

Years	Testing Method(s)	Diseases Detected	Significance
Late 1800s			
1940s			
1990s			
2000s			
Challenges in wastewater analysis			
Future needs			

Summary: On the back of this paper, write a one-sentence summary (18 words or less) explaining the importance of wastewater surveillance.

Answers to Reading Comprehension Questions & Graphic Organizer Rubric

1. Who was the first person to track diseases through a population? When did this happen? What was the disease?
   John Snow in 1854 tracked cholera cases in London, England.

2. State 2-3 other times in the past diseases were tracked. Include the years and the diseases that were tracked.
   1940's James Trask and John Paul tracked polio in sewage.
   1990's Hepatitis A was tracked
   2013 both hepatitis A and norovirus were both tracked in Sweden.
   2020 to present - COVID-19
   2025 Measles

3. Briefly explain how scientists safely neutralize and prep wastewater before they analyze it.
   The scientists expose the wastewater with ultraviolet rays and heat to destroy hazards, such as pathogenic (deadly or disease-causing) organisms, and then homogenize (mix well to evenly distribute all dissolved materials) and finally they concentrate the samples.

4. Explain another way wastewater tracking is used, other than sewers or water treatment plants.
   The tracking is also used in airports and airplanes to test for new viruses and to track global spread.

5. How similar is the DNA of humans?
   Human DNA is 99.9% the same for all humans.

6. Why did scientists need to find a way to make more of the DNA of the diseases they are studying?
   The amount of DNA in the samples was too small to test, so scientists had to make copies of the DNA.

7. What is the process to replicate DNA called? How does this work?
   Polymerase Chain Reaction (PCR) is the process in which scientists can replicate a single strand of DNA almost a million times. It happens by splitting the double stranded DNA and then using primers and introducing complementary base pairs to replicate the DNA sequences.

8. Why is it harder to track diseases in rural areas of the country?
   In rural areas, homes have individual septic tanks for waste as opposed to a city sewer system. Therefore, there is no central system to test for diseases.

9. What could be some other uses for PCR?
   Anytime scientists need DNA for studies, they can use the PCR process. A few examples could be for genetic testing such as that methods used in Ancestry.com, or for forensic science such as identifying a rapist by matching DNA samples from skin, hair or semen.

10. What could be some possible issues that could be problematic for wastewater testing?
    Timing could be an issue, if the testing is done too early to detect anything, or too late in the spread of the disease. There could also be some issues of privacy when testing and how the data can be used on the population being tested. Whole countries could be affected, if testing finds contagious diseases, that could affect tourism.

Questions for Further Learning

11. Suppose you were told that the wastewater from your school will be tested for one or more suspected diseases that may be spread. What would the pros and cons be? How would you feel about this happening? What do you think the school should do if the tests showed that a communicable disease was possibly carried by one of the members of your school?
    Answers may vary. Some pros would be: the school can better find out what disease is present in the school, and how prevalent it is. The testing can also help in prevention; if the school finds something early, the administration can take steps to slow or stop the spread.

    Some cons would be privacy; some students will feel singled out if others believe that they were the ones with the disease.

    Possible solutions would be to prohibit the affected students from coming back to school until they test negative, or, in a worst-case scenario, the school must shut down for a number of days until the disease passes through the student population.

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

Assignment

Ingenious: The World's Smallest Water Treatment Plant Comes in a Packet Video Questions
https://teachchemistry.org/classroom-resources/ingenious-the-world-s-smallest-water-treatment-plant-comes-in-a-packet-video-questions

Project

Wastewater Recovery
https://teachchemistry.org/classroom-resources/wastewater-recovery

Lab

Hands-on Activity: Tracking a Virus
https://www.teachengineering.org/activities/view/duk_virus_mary_act

Infographic

The Chemistry Behind Your Home's Water Supply
https://www.compoundchem.com/2016/04/21/water-treatment/

Teaching Strategies

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

- **Alternative to Anticipation Guide:** Before reading, ask students how scientists might track communicable diseases. Ask how disease tracking has changed over time, and why. 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 successes and challenges in tracking disease outbreaks. Ask them to think about how they might use this information in the future.

Chemistry Concepts and Standards

Connections to Chemistry Concepts

The following chemistry concepts are highlighted in this article:

- Biochemistry
- Instrumentation
- Scientific method

Correlations to Next Generation Science Standards

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

HS-ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

Disciplinary Core Ideas:

- ETS1.A: Defining and delimiting engineering problems

Crosscutting Concepts:

- Scale, proportion, and quantity
- Systems and system models
- Cause and effect

Science and Engineering Practices:

- Asking questions and defining problems
- Planning and carrying out investigations
- Using mathematics and computational thinking

Nature of Science:

- Scientific knowledge is based on empirical evidence.

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