



<http://www.asc.org/chemmatters>

**“Dental Fillings: A Reaction in Your Mouth”**

*(October/November 2017 Issue)*

**Teacher’s Guide**



**Teacher's Guide for**

***Dental Fillings: A Reaction in Your Mouth***

**October/November 2017**

**Table of Contents**

[Connections to Chemistry Concepts 3](#_Toc493856424)

[Teaching Strategies and Tools 4](#_Toc493856425)

[Standards 4](#_Toc493856426)

[Vocabulary 4](#_Toc493856427)

[Reading Supports for Students 6](#_Toc493856428)

[Anticipation Guide 8](#_Toc493856429)

[Graphic Organizer 9](#_Toc493856430)

[Student Reading Comprehension Questions 9](#_Toc493856431)

[Answers to Student Reading Comprehension Questions 12](#_Toc493856432)

[Possible Student Misconceptions 14](#_Toc493856433)

[Anticipating Student Questions 15](#_Toc493856434)

[Activities 16](#_Toc493856435)

[References 18](#_Toc493856436)

[Web Sites for Additional Information 20](#_Toc493856437)

[About the Guide 23](#_Toc493856438)

# Connections to Chemistry Concepts

|  |  |
| --- | --- |
| **Chemistry Concept** | **Connection to Chemistry Curriculum** |
| **Alloys** | Some students may have silver-colored dental amalgam fillings, or at least they have heard about them. Connecting this common dental material (containing mixtures of mercury, silver, tin, and/or copper) to alloys can provide an example other than the common steel, brass, and bronze examples used in class. |
| **Polymers** | Students may be familiar with common polymers, including polyester, cellulose, and polyethylene, but they may not know that white-colored, composite dental resins are a commonly-used and very strong polymer. Understanding how polymers form from monomer units and how they are useful in our lives (including less familiar polymers like those in dentistry) may be insightful for students. |
| **Covalent bonding** | In addition to the traditional study of covalent bonds in hydrocarbons, students may better relate to the covalent bonds formed during polymerization of composite resins in their dental fillings. Often thought of as weaker bonds, covalent bonds can create large and strong molecules capable of withstanding the tremendous forces (275 pounds) in a human bite. |
| **Polar molecules** | The hydrophobic polymer in composite dental resins and the hydrophilic silica-based glass provide teachers with an opportunity to discuss the polarity of molecules and why those polar charges occur, using the example of students' dental fillings. In particular, the hydroxyl groups in both the composite resin silica-based glass reinforcement material and the silanes used as a coupling agent provide opportunities for understanding polar molecules and their interactions. |
| **Chemical properties and reactivity** | A discussion of why gold was used in the past as a dental filling could lead students into a discussion of chemical properties and reactivity. Why was copper not used, or iron? The characteristics which make dental amalgam or composite resins preferable as dental fillings over gold could include costs, hardness, non-reactivity, availability, aesthetics, etc. |
| **Materials science** | The development of composite resins for dental fillings in the 1990s is an example of materials science at work. Moving from gold, to amalgam, to composites illustrates the process of material science research to meet the needs of humans by modifying the materials around them for better lives. |

# Teaching Strategies and Tools

## Standards

* Links to **Common Core Standards for Reading**:

**ELA-Literacy.RST.9-10.1.** Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.

**ELA-Literacy.RST.9-10.5.** Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).

**ELA-Literacy.RST.11-12.1.** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

**ELA-Literacy.RST.11-12.4.** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics.

* Links to **Common Core Standards for Writing**:

**ELA-Literacy.WHST.9-10.2F.** Provide a concluding statement or section that follows from and supports the information or explanation presented (e.g., articulating implications or the significance of the topic).

**ELA-Literacy.WHST.11-12.1E.** Provide a concluding statement or section that follows from or supports the argument presented.

* Links to **Next Generation Science Standards**

**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**:
* LS1.A: Structure and function
* PS1.A: Structure and properties of matter
* ETS1.B: Optimizing the design solution
	+ **Crosscutting Concepts:**
* Systems and system models
* Stability and change
* Structure and function
	+ **Science and Engineering Practices:**
* Asking questions (for science) and defining problems (for engineering)
* Obtaining, evaluating, and communicating information
	+ **Nature of Science:**
* Scientific knowledge is based on empirical evidence.
* Scientific knowledge assumes an order and consistency in natural systems

## Vocabulary

**Vocabulary** and **concepts** that are reinforced in the October/November 2017 issue:

* + Equilibrium
	+ Solute and solvent
	+ Electrolyte
	+ Ions
	+ Lipids
	+ Osmosis
	+ Metallic and nonmetallic
	+ Igneous, sedimentary, metamorphic rocks
	+ Composting
	+ Aerobic and anaerobic
	+ Carcinogen
	+ Heavy metals
	+ Amalgam
	+ Polymerization
	+ Composites

# Reading Supports for Students

The pages that follow include reading supports in the form of an Anticipation Guide, Reading Strategies, a Graphic Organizer, and Student Reading Comprehension Questions. These resources are provided to help students as they prepare to read and in locating and analyzing information from the article.

The borders on these pages distinguish them from the rest of the pages in this Teacher’s Guide—they have been formatted for ease of photocopying for student use.

* **Anticipation Guide (p. 8):** The Anticipation Guide helps to engage students by activating prior knowledge and stimulating student interest before reading. If class time permits, discuss students’ responses to each statement before reading each article. As they read, students should look for evidence supporting or refuting their initial responses.
* **Graphic Organizer (p. 9):** The Graphic Organizer is provided to help students locate and analyze information from the article. Student understanding will be enhanced when they explore and evaluate the information themselves, with input from the teacher, if students are struggling. Encourage students to use their own words and avoid copying entire sentences from the article. The use of bullets helps them do this.

If you use the aforementioned organizers 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 |

* **Student Reading Comprehension Questions (p. 10):** The Student Reading Comprehension Questions are designed: to encourage students to read the article (and graphics) for comprehension and attention to detail; to provide the teacher with a mechanism for assessing how well students understand the article and/or whether they have read the assignment; and, possibly, to help direct follow-up, in-class discussion, or additional, deeper assignments.
* This issue supports the 2017 National Chemistry Week theme of “Chemistry Rocks!”
* Most of the articles in this issue provide opportunities for students to consider how understanding chemistry can help them in their personal lives.
* To help students engage with the text, ask students which article engaged them most and why, or what questions they still have about the articles.
* You might also ask them how information in the articles might affect their health and/or consumer choices. Also ask them if they have questions about some of the issues discussed in the articles.
* The Background Information in the *ChemMatters* Teachers Guide has suggestions for further research and activities.

“Dental Fillings: A Reaction in Your Mouth”, *ChemMatters*, October/November 2017 Issue

Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

## Anticipation Guide

“A Close-up Look at the Quality of Indoor Air” (*ChemMatters*, April/May 2016 Issue)

**Directions:**  ***Before reading the article*,** in the first column, write “A” or “D,” indicating your agreement or disagreement with each statement. 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. About half of the high school students in the U. S. have tooth decay.
 |
|  |  | 1. Amalgam dental fillings contain mercury and other metals.
 |
|  |  | 1. Composite resins, which are white, are used for dental fillings today.
 |
|  |  | 1. Monomers have the same properties than the polymers they form.
 |
|  |  | 1. Polymerization to form dental resins begins spontaneously when molecules of the monomer are present.
 |
|  |  | 1. Blue light is used by dentists to trigger polymerization.
 |
|  |  | 1. The polymer in dental resins attracts water.
 |
|  |  | 1. Hydroxyl (OH-) groups are attracted to water.
 |
|  |  | 1. Dental resins are reinforced with silica-based glass.
 |
|  |  | 1. Composite-resin fillings include dyes to match a patient’s tooth color.
 |

## Graphic Organizer

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

“Dental Fillings: A Reaction in Your Mouth”, *ChemMatters*, October/November 2017 Issue

**Directions**: ***As you read***, complete the graphic organizer below to describe what you learned about the chemistry of composite resin dental fillings.

|  |
| --- |
| **Composite Resin Dental Fillings** |
| Why are they used? |  |
| What is the role of polymerization in creating the fillings? |  |
| Why is blue light used? |  |
| Why are particles of silica-based glass added to the dental resin? |  |
| How do coupling agents help create the dental resin? |  |

**Summary**: On the back of this paper, use information from the article to write a tweet (140 characters or less) about dental resins.

## Student Reading Comprehension Questions

“Dental Fillings: A Reaction in Your Mouth”, *ChemMatters*, October/November 2017 Issue

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Name

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

* 1. What fraction of high school students in the United States have tooth decay?
	2. List five desirable characteristics of an ideal dental filler for sealing a tooth.
	3. What are three common types of dental fillings?
	4. What are three drawbacks to the use of silver (amalgam) fillings?
	5. Provide four advantages of using composite resin fillings.
	6. What is one example of a thoroughly cross-linked polymer that is one big molecule?

**Student Reading Comprehension Questions, cont.**

“Dental Fillings: A Reaction in Your Mouth”, *ChemMatters*, October/November 2017 Issue

* 1. What are free-radicals?
	2. Explain why dental resins are poured in thin layers until the cavity is filled.
	3. Why is a coupling agent included in dental resins?
	4. Identify the two parts of composite materials. For dental resin, what material is used for each of these two composite parts?
	5. Dental resin composites contain materials that are hydrophobic and hydrophilic. What do these two terms mean?
	6. Name three actions students can take to prevent tooth decay.

## Answers to Student Reading Comprehension Questions

1. **What fraction of school students in the United States have tooth decay?**

*Approximately half of high school students in the United States have tooth decay.*

1. **List five desirable characteristics of an ideal dental filler for sealing a tooth.**

*Five desirable characteristics of an ideal dental filler for sealing a tooth include:*

1. *it must be soft and malleable when applied,*
2. *it must harden once in place,*
3. *it must be resistant to chewing,*
4. *it must be chemically stable, and*
5. *it must be biocompatible.*
6. **What are three common types of dental fillings?**

*Three common types of dental fillings are*

1. *gold,*
2. *amalgam, and*
3. *composite resins.*
4. **What are three drawbacks to the use of silver (amalgam) fillings?**

*Three drawbacks to the use of silver or amalgam fillings are*

*the filling is unattractive in the mouth,*

*the amalgam does not stick to the tooth, so extra healthy tooth must be removed to anchor the amalgam, and*

*there are concerns about mercury in the amalgam leaking from the filling.*

1. **Provide four advantages of using composite resin fillings.**

*Four advantages of using composite resin fillings are*

*they match the tooth color,*

*they are soft and easily applied,*

*they solidify quickly to a hard solid, and*

*they last a long time.*

1. **What is one example of a thoroughly cross-linked polymer that is one large molecule?**

*One example of a thoroughly cross-linked polymer that is one big molecule is a resin bowling ball.*

1. **What are free radicals?**

*Free radicals are molecules that have unpaired electrons.*

1. **Explain why dental resins are poured in thin layers until the cavity is filled.**

*Dental resins are poured in thin layers until the cavity is filled because the blue light used to induce polymerization of the resin can only travel a few millimeters into the filling. Therefore, the resin must be poured in layers to allow each layer, exposed to the blue light, to properly polymerize and harden.*

1. **Why is a coupling agent included in dental resins?**

*A coupling agent is included in dental resin because the polymer is hydrophobic and the silica-based glass is hydrophilic. The coupling agent is needed to bond the polymer to the silica.*

1. **Identify the two parts of a composite materials. For dental resin, what material is used for each of these composite parts?**

*The two parts of a composite material are the matrix and the reinforcement (or filler).
In dental resin, the matrix is the polymer and the reinforcement material (or filler) is the silica.*

1. **Dental resin composites contain materials that are hydrophobic and hydrophilic. What do these two terms mean?**

*The term hydrophobic means that the material does not mix with water. The term hydrophilic means that the material attracts water.*

1. **Name three actions students can take to prevent tooth decay.**

*Three actions that students can take to prevent tooth decay include*

1. *limiting the consumption of sugar and carbohydrates,*
2. *brushing and flossing daily, and*
3. *seeing a dental hygienist regularly.*

# Possible Student Misconceptions

1. **“My friend said that I need to have the silver-colored (amalgam) fillings in my teeth removed so I don't get mercury poisoning.”** *The U.S. Food and Drug Administration (FDA) advises that if the fillings are in good condition and there is no tooth decay below the filling then there is no need to replace the amalgam fillings with new ones. The unnecessary removal and replacement of amalgam fillings can lead to loss of healthy tooth structure and possible exposure to additional mercury vapor in the process of removal.*
2. **“I heard that silver fillings can cause Alzheimer's disease”** *"According to the best available scientific evidence, there is no relationship between silver dental fillings and Alzheimer's… Public health agencies, including the FDA, the U.S. Public Health Service and the World Health Organization, endorse the continued use of amalgam as safe, strong, inexpensive material for dental restorations."* *(*[*http://www.alz.org/alzheimers\_disease\_myths\_about\_alzheimers.asp*](http://www.alz.org/alzheimers_disease_myths_about_alzheimers.asp)*)*
3. **“Sugar causes tooth cavities.”** *Sugar can be contribute to dental cavities, but other culprits include carbohydrates such as pasta, breads, fruits, beans, and desserts. However, it's not the sugar or the carbohydrates that cause the actual dental decay and cavities. It is, instead, the acids produced as waste by bacteria in the mouth as they digest these sugars and carbohydrates that cause the cavities. It is important to remove these acids from the teeth by rinsing, brushing, and flossing teeth at least twice a day so the acids do not accumulate and eat away at the teeth.*

# Anticipating Student Questions

1. **“How long can the fillings in my teeth last?”** *Different types of dental fillings have different durabilities. Typically, cast gold fillings can last at least 10–15 years, or longer, with proper care. The amalgam (silver) fillings can last at least 10–15 years. The composite resin fillings are less durable and last at least five years, but they may not last as long if used in large cavities or on chewing surfaces of the teeth.*
2. **“What causes cavities in my teeth?”** *Tooth decay or a cavity is caused by the reaction of acids on teeth. The acids are produced as a waste by bacteria in the mouth digesting foods, especially sugars and starches, and changing them into the acids. The bacteria, saliva, food, and resulting acids form a very sticky substance called plaque which sticks to the teeth. This plaque accumulates most commonly on the back molars, around the gum line, and around the edges of dental fillings. The acids trapped in the plaque (which builds up on teeth within 20 minutes after eating) erode the enamel of the tooth and creates holes called cavities (also called dental caries).*
3. **“If mercury is toxic, why is it used in dental fillings?”** *About half of the dental amalgam in a silver-colored filling is made of mercury. The mercury is used to dissolve and bind the other metals (silver, tin, and copper) into a strong and stable filling. Mercury's unique property of being a liquid metal at room temperature makes it easy to form the durable amalgam filling at room temperature, which is safe for the patient. All of the credible scientific evidence reviewed by the FDA, and the clinical studies conducted in adults and children above age 6 and adults, have found no links between dental amalgam fillings and health problems.*

# Activities

**Labs and Demos**

**Dental chemistry lab:** Students design their own experiment to investigate the effects of fluoride treatment on teeth using sodium fluoride solution and marble chips or eggshells as a substitute for teeth. "Dental Chemistry Analogy" from Terrific Science includes student materials and extensive instructor notes. (<http://www.terrificscience.org/lessonpdfs/03DentalChem.pdf>)

**Simulations**

**Simulation of condensation and hydrolysis reactions:** *Biomolecules* contains a simple simulation activity, “Building and Breaking Biomolecules”, where students can build and label a simple dimer molecule through a condensation (or dehydration synthesis) reaction and follow with a hydrolysis reaction. (<https://dlc.dcccd.edu/biology1-3/functional-groups-and-biomolecules>)

**Animated simulation of condensation and hydrolysis:** "Condensation and Hydrolysis – Cengage" provides a simple, clear audio and visual representation of both condensation and hydrolysis reactions with organic molecules. (<http://www.cengage.com/biology/discipline_content/animations/reaction_types.html>)

**Media**

**Infographic of "The Chemistry of Dentistry":** This infographic illustrates the topics of “Tooth Decay”, “Fluoride Versus Tooth Decay”, “Fillings and Composites”, and “Teeth Whitening”. (<http://cen.acs.org/articles/94/i24/Periodic-Graphics-chemistry-dentistry.html>)

**PowerPoint on dental materials:** This 52-slide presentation, "Restorative and Esthetic Dental Materials", discusses amalgams, composite resins, glass ionomers, gold alloys, porcelain, and other dental materials. Indications for use, concerns, preparation, and application of these materials is provided. (<http://www.csi.edu/facultyAndStaff_/webTools/sites/Bowcut58/courses/552/ch43.ppt>)

**Video of dental cavity formation:** "What Is a Cavity?" (6:45) shows the formation of a dental cavity. The video discusses the biotic conditions responsible for dental acid formation through animation. (<https://www.youtube.com/watch?v=hTK0iua4tNA&t=119s>)

**Lessons and Lesson Plans**

**Dentistry polymers lesson:** The Royal Society of Chemistry publishes an eight-page lesson, "Polymers in Everyday Things—Dentistry", with background information on different types of dental fillings but focusing on dentistry polymers. The lesson includes a four-page worksheet for students but has no teacher support materials. (<http://www.rsc.org/Education/Teachers/Resources/Inspirational/resources/3.1.2.pdf>)

**Lesson plan for metal alloys:** A sequence of lessons for studying metal alloys is structured with reading, videos, and a summary task for students, with aluminum alloys. The Web site also includes links to lessons on ceramics, polymers, and composites, all of which are other types of materials used in dentistry. (<https://www.e-education.psu.edu/matse81/node/2140>)

**Projects and Extension Activities**

**Dental science fair projects and experiments:** Suggestions for science fair projects and experiments, including natural substances for whitening teeth, amalgam toxicity, effectiveness of different teeth cleaners on bacteria, the effect of acids on amalgam, and how teeth are affected by fluoride and acids are provided at <http://www.juliantrubin.com/fairprojects/medicine/dentistry.html>.

**Teaching dental health to elementary students:** Dental health is typically taught to students in early elementary grades. High school students could develop and teach lessons for elementary students using content, demonstrations, and experiments similar to those at <https://www.deltadentalnj.com/kidsclub/kids_experiments.html>.

# References

**The references below can be found on the *ChemMatters* 30-year DVD, which includes all articles
published from the magazine’s inception in October 1983 through April 2013; all available Teacher’s Guides, beginning February 1990; and 12 *ChemMatters* videos. The DVD is available from the American Chemical Society for $42 (or $135 for a site/school license) at this site:** [**http://ww.acs.org/chemmatters**](http://www.acs.org/chemmatters)**. Click on the “Teacher’s Guide” tab to the left, directly under the “*ChemMatters Online"* logo and, on the new page, click on “Get the past 30 Years of *ChemMatters* on DVD!” (the icon on the right of the screen)**

**Selected articles and the complete set of
Teacher’s Guides for all issues from the past three
years are available free online at the same Web site, above. Click on the “Issues” tab just below the logo, *“ChemMatters Online”*.**

***30* Years of *ChemMatters !***

Available Now!

"Toothpaste", a complementary *ChemMatters* article to the Pistoi dental fillings article, includes the chemical reactions for the demineralization of dental enamel, a discussion of pH and acids produced by oral bacteria, and suggestions for preventing tooth decay. While the 1986 article is in black and white only, the chemistry and content are accurate and useful. (Yohe, B. Toothpaste. *ChemMatters*, 1986, *4* (1), pp 12–13)

 "Tooth Decay: A Delicate Balance" is a wonderful companion to the Pistoi dental fillings article, providing a discussion of the acids that cause tooth decay and the equilibrium (and Le Châtelier's Principle) occurring to reverse that decay. The article provides details about acids, bases, buffers, and equilibrium associated with tooth decay. (Warmflash, D. Tooth Decay: A Delicate Balance. *ChemMatters*, 2015, *33* (3), pp 8–10)

 The Teacher's Guide for "Tooth Decay: A Delicate Balance" (see above) supplies in-depth information on tooth structure, the chemistry of tooth decay, fluoride tooth treatments, dental fillings, tooth decay prevention, amalgam, and composite dental fillings. Additional activities and Web links to these same topics are included.

 "Brush Up on Toothpaste!" explains how to reduce or prevent dental fillings through the chemical and physical action of toothpaste. Demineralization of tooth enamel from bacterial acids, biofilms, and the physical act of brushing teeth are detailed in this excellent supporting article. (Brown, V. Brush Up on Toothpaste! *ChemMatters*, 2017, *35* (1), pp14–15)

 The Teacher's Guide for "Brush Up on Toothpaste!" (see above) provides additional content on tooth decay, oral bacteria, demineralization and remineralization of teeth, and the components of toothpaste, all of which complement the dental fillings article. Additional Web links, references, and a lab related to tooth decay are also supplied.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

 Five assessment questions for college general chemistry (adaptable for high school use) applied to fluorine compounds in dentistry are provided in this article. Chemistry concepts covered by the questions (with answers supplied) are: stoichiometry, concentration units, resonance, geometry of polyatomic ions, bond length, and bond order. (Pinto, G. Fluorine Compounds and Dental Health: Applications of General Chemistry Topics. *J. Chem. Educ.*, 2009, *86* (2), pp 185–187; <http://pubs.acs.org/doi/pdf/10.1021/ed086p185>. Note that this link takes you to a brief abstract only, the full article is only available to American Chemical Society members or subscribers to the journal.)

 This article reviews the chemistry of dental materials from past issues of the *Journal of Chemical Education*. Topics included in the review are toothpaste, dental restoration, and amalgams. (Williams, K. Behind the Scenes at the Toothpaste Aisle: The Chemistry of Dental Materials. *J. Chem. Educ.*, 2010, *87* (10), pp 1007–1008; <http://pubs.acs.org/doi/abs/10.1021/ed1004992>. Note that this link goes to a brief abstract only, the full article is only available to American Chemical Society members or subscribers to the journal.)

 Safety concerns of dental amalgams and identifying appropriate biomarkers for measuring the exposure to mercury from the amalgams are reported in this article summarizing U.S. Food and Drug Administration hearings. (Erickson, B. FDA Revisits Dental Amalgams. *Chem. Eng. News*, 2011, *89* (5), pp 40–41; <http://pubs.acs.org/doi/abs/10.1021/cen-v089n005.p040>. Note that this link provides a brief abstract only, the full article is only available to American Chemical Society members or subscribers to the journal.)

# Web Sites for Additional Information

**Dental history timeline**

 The American Dental Association provides a *History of Dentistry Timeline,* with subsections on “Ancient Origins”, “The Beginnings of a Profession—Middle Ages”, “The Development of a Profession—18th Century”, “Advances in Science and Education—19th Century”, and “Innovations in Techniques and Technology—The 20th Century”. (<http://www.ada.org/en/about-the-ada/ada-history-and-presidents-of-the-ada/ada-history-of-dentistry-timeline>)

**Tooth decay**

 The chemistry of tooth decay is explained in "Sugar and Tooth Decay". Chemical structures are used to illustrate the conversion of sucrose into lactic acid as it applies to tooth decay. (<http://chemistry.elmhurst.edu/vchembook/548toothdecay.html>)

 A clinical description of tooth decay is provided in "Microbiology of Dental Decay and Periodontal Disease". The article discusses the bacterial aspects of tooth decay and the role of *Streptococcus mutans*. (<https://www.ncbi.nlm.nih.gov/books/NBK8259/>)

**Comparing types of dental fillings**

"Types of Fillings" compares the advantages and disadvantages of the common dental fillings of amalgam, composite resin, cast gold, ceramics, and glass ionomers. (<http://www.colgate.com/en/us/oc/oral-health/procedures/fillings/article/types-of-fillings>)

 "Dental Health and Tooth Fillings" contains numerous links on the Web site listing the advantages and disadvantages (including durability, aesthetics, and expense) of cast gold, amalgam, composite, and other dental fillings. ((<http://www.webmd.com/oral-health/guide/dental-health-fillings>)

**Gold fillings**

"Gold in Dentistry: Alloys, Uses, and Performance" explains how 70 tons of gold are used annually in dentistry. The current uses of gold and newer techniques, including electroforming, are explained, along with suggestions for future development. (<https://link.springer.com/article/10.1007/BF03215496>)

 A 1981 article, "Dental Gold Alloys: Composition, Properties, and Applications", discusses the properties of gold that have led to its wide use in dentistry. The chemical and physical properties of different gold alloys used in a variety of dental applications are explained. (<https://link.springer.com/article/10.1007/BF03214598>)

**Amalgam fillings**

The U.S. Food and Drug Administration's Web site, "About Dental Amalgam Fillings", discusses amalgam fillings, their benefits and risks, the use of mercury in the amalgams, and whether existing amalgam fillings should be removed. (<https://www.fda.gov/medicaldevices/productsandmedicalprocedures/dentalproducts/dentalamalgam/ucm171094.htm>)

 "Dental Amalgam: An Update" reviews the history and the future of this common dental filling. Topics discussed in the article include its durability, toxicity, composition, and several variations on the traditional amalgam. (<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3010024/>)

**Composite resin fillings**

 "New Materials to Take a Bite out of Tooth Decay" explains the shift in dental fillings from gold and amalgam to polymer composite resins. Newer techniques for dental repairs, such as biomaterials and cavity-arresting alternatives, are included. (<http://cen.acs.org/articles/94/i31/New-materials-take-bite-tooth.html>)

 "Composite Materials: Composition, Properties, and Clinical Applications" provides an in-depth look at dental resin composites. Methacrylate polymers with different fillers are analyzed for their advantages and disadvantages in various dental applications. (<https://www.sso.ch/fileadmin/upload_sso/2_Zahnaerzte/2_SDJ/SMfZ_2010/SMfZ_11_2010/smfz_11_2010_research1.pdf>)

**Glass ionomers**

 Glass ionomers are dental cements that bond to teeth and release fluoride for a long time and can be used as dental fillings when paired with appropriate fillers. The advantages and disadvantages of glass ionomers are described in "A Review of Glass Ionomer Restorations in the Primary Dentition". (<https://www.cda-adc.ca/jcda/vol-65/issue-9/491.html>)

 "20 Tips for Using Glass Ionomers" shows pictures of teeth being repaired with glass ionomers (GI). While written as for dentists, the publication provides insight into how and why GI can be used for dental restoration. (<http://www.aacd.com/proxy/files/Students%20and%20Faculty/20%20tips%20Glass%20Ionomers.pdf>)

**Curing composite resins with blue light**

 "The Physics of Light Curing and its Clinical Implications" is a brief description of how light curing works in dental composite resins. Both older ultraviolet devices and newer LED lights are discussed. (<https://www.dentalaegis.com/cced/2011/08/the-physics-of-light-curing-and-its-clinical-implications>)

 "Cure Mechanisms in Materials for Use in Esthetic Dentistry" is a technical explanation of how dental resins are cured (or hardened) using heat, light, or self-cure techniques. Chemical structures and reactions are included in the article. (<https://www.researchgate.net/publication/221799494_Cure_mechanisms_in_materials_for_use_in_esthetic_dentistry>)

**Bis-GMA**

One of the most common composite dental resins is Bis-GMA (Bisphenol A glycidylmethacrylate). This Web site provides a technical chemical compound summary for this substance and links to Web sites and publications where Bis-GMA is cited. (<https://pubchem.ncbi.nlm.nih.gov/compound/Bis-gma>)

 The toxicity and causes of degradation of composite dental resins, including Bis-GMA, are described in "Release and Toxicity of Dental Resin Composite". This technical article concludes that newer composites are safer when used appropriately, but more studies are needed to understand the biocompatibility of these resins. (<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3532765/>)

# About the Guide

Teacher’s Guide team leader William Bleam and editors Pamela Diaz, Steve Long and Barbara Sitzman created the Teacher’s Guide article material.

E-mail: bbleam@verizon.net

Susan Cooper prepared the anticipation and reading guides.

Terri Taylor, *ChemMatters* Teacher’s Guide interim editor, coordinated production and prepared the Microsoft Word and PDF versions of the Teacher’s Guide.

E-mail: chemmatters@acs.org

Articles from past issues of *ChemMatters* and related Teacher’s Guides can be accessed from a DVD that is available from the American Chemical Society for $42. The DVD contains the entire 30-year publication of *ChemMatters* issues, from February 1983 to April 2013, along with all the related Teacher’s Guides since they were first created with the February 1990 issue of *ChemMatters*.

The DVD also includes Article, Title, and Keyword Indexes that cover all issues from February 1983 to April 2013. A search function (similar to a Google search of keywords) is also available on the DVD.

The *ChemMatters* DVD can be purchased by calling 1-800-227-5558. Purchase information can also be found online at <http://tinyurl.com/o37s9x2>.