

**February/March 2017 Teacher's Guide for**

***Iron in the Diet: Power on Your Plate?***

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# About the Guide

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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:

<https://www.acs.org/content/acs/en/education/resources/highschool/chemmatters/products.html>.

# Student Questions

**Iron in the Diet: Power on Your Plate?**

* 1. How much iron does your body contain?
	2. What group of people is most affected by the lack of iron in the body?
	3. What are the three main reasons given in this article for iron deficiency?
	4. What is the usual daily requirement for teenagers?
	5. What are the most common oxidation states for iron?
	6. In what oxidation state is iron stored in the body?
	7. What is the source of heme iron? Give one example of such a source mentioned in the article.
	8. Why is heme iron more bioavailable than non-heme iron?
	9. Name two substances that inhibit the bioavailability of iron that are mentioned in the article.
	10. What are the symptoms of iron-deficiency anemia cited in the article?
	11. List the three health problems cited in the article that are caused by excess iron in the body.

# Answers to Student Questions

**(taken from the article)**

**Iron in the Diet: Power on Your Plate?**

* + 1. **How much iron does your body contain?**

*Your body contains about 3.5 grams if you are a female, while a male has about 4 grams.*

* + 1. **What group of people is most affected by the lack of iron in the body?**

*The poor, especially infants, children and women, are most greatly affect by the lack of iron. Also, fast growing teens and menstruating teenage girls can be affected by iron deficiency.*

* + 1. **What are the three main reasons given in this article for iron deficiency?**

*The three main reasons for iron deficiency are:*

1. *iron is lost in body fluids, such as blood, sweat and tears,*
2. *people may have diets that do not contain enough iron, and*
3. *the digestive system discards most of the iron you eat.*
	* 1. **What is the usual daily requirement for teenagers?**

*The daily requirement for iron is 11 milligrams for teenage boys and 15 milligrams for teenage girls.*

* + 1. **What are the most common oxidation states for iron?**

*The most common oxidation states of iron are Fe+2 (ferrous) and Fe+3 (ferric).*

* + 1. **In what oxidation state is iron stored in the body?**

*The body stores iron in the iron(III) oxidation state.*

* + 1. **What is the main source of heme iron? Give one example of such a source mentioned in the article.**

*The main source of heme iron is from animals. Steak is an example of such a source.*

* + 1. **Why is heme iron more bioavailable than non-heme iron?**

*Heme iron is already in an iron(II) oxidation state, which is the form of iron most often required by the body. It is already attached to protein molecules and is more soluble, which makes it more readily absorbed by the body.*

* + 1. **Name two substances that inhibit the bioavailability of iron that are mentioned in the article.**

*Two substances mentioned in the article that inhibit bioavailability are*

* 1. *calcium and*
	2. *polyphenols, antioxidants that bind with iron to inhibit absorption.*
		1. **What are the symptoms of iron-deficiency anemia cited in the article?**

*The symptoms of iron-deficiency anemia include*

1. *low energy levels,*
2. *weak muscles,*
3. *racing heart,*
4. *pounding headaches,*
5. *skin and nails becoming dry and yellow, and*
6. *hair falling out.*
	* 1. **List the three health problems cited in the article that are caused by excess iron in the body.**

*The three health problems caused by excess iron are*

* 1. *cancer,*
	2. *heart attack, and*
	3. *possibly, accelerated Alzheimer’s disease*

# Anticipation Guide

Anticipation guides help 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.

**Directions:**  *Before reading*, 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. There is enough iron in your body to make one medium-sized nail.
 |
|  |  | 1. Iron is more abundant than sulfur in the body.
 |
|  |  | 1. Iron deficiency is the most common nutritional disorder in the world.
 |
|  |  | 1. Teenage boys need more iron than teenage girls.
 |
|  |  | 1. Iron is stored as iron (III) in the body, but we need iron (II).
 |
|  |  | 1. Iron we eat comes from “heme” and “non-heme” sources, and both have the same bioavailability to our bodies.
 |
|  |  | 1. Hemoglobin is a protein containing one iron (II) ion (ferrous ion).
 |
|  |  | 1. It is very easy for a healthy person to get too much iron in the diet.
 |
|  |  | 1. Calcium may aid the absorption of both heme and non-heme iron.
 |
|  |  | 1. Symptoms of too much iron are similar to those of too little iron.
 |

# Reading Strategies

These graphic organizers are provided to help students locate and analyze information from the articles. 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 articles. The use of bullets helps them do this. If you use these reading and writing strategies 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 |

***Teaching Strategies:***

* Links to **Common Core State 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.
* **Vocabulary** and **concepts** that are reinforced in this issue:
	+ Chemical and physical properties
	+ Chemical reactions
	+ Viscosity
	+ Personal and community health
	+ Oxidation states
	+ Elements
	+ Conservation of matter
	+ Consumer choices
	+ Recycling
* Most of the articles in this issue provide opportunities for students to consider how understanding chemistry can help them make informed choices as consumers. The articles also connect chemistry and engineering.
* Consider asking students to read “Open for Discussion” on page 4 to extend the information in “The Drive for Cleaner Emissions” on pages 5-7.
* The infographic on page 19 provides more support for the article “Brush Up on Toothpaste!” on pages 14-15.
* 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 choices as consumers. Also ask them if they have different ideas to solve some of the problems discussed in the articles.
* The Background Information in the *ChemMatters* Teachers Guide has suggestions for further research and activities.

***Directions*:** As you read the article, complete the graphic organizer below to describe the importance of iron in your diet.

|  |  |
| --- | --- |
|  | **Importance and chemistry involved** |
| **Iron deficiency** |  |
| **Sources of iron** |  |
| **Heme iron** |  |
| **Non-heme iron** |  |
| **Bioavailability** |  |

**Summary:** On the back of this page, write a few sentences describing what you learned about the importance of iron in your diet, including if you want to make any changes in your diet based on information in the article.

# Connections to Chemistry Concepts

**(for correlation to course curriculum)**

1. **Descriptive chemistry**—This article can be used to teach some of the properties of iron, as well as the role it plays in living organisms.
2. **Oxidation and Reduction**—The discussion of the oxidation states of iron in the article provides great examples of the importance of oxidation-reduction reactions. The article can be used to show how the oxidation state affects the properties of a specie by examining how the body uses iron (II) and iron (III).
3. **Biochemistry**—The discussion of heme iron versus non-heme iron and how the body uses each provides an example of how diet can affect your health.
4. **Organic chemistry**—Students can identify functional groups in the heme unit.

# Possible Student Misconceptions

**(to aid teacher in addressing misconceptions)**

1. **“Vegetarians have a higher risk of iron deficiency.”** *Although vegetarians do not eat meat, fish and poultry that contain more readily-absorbed heme iron, research has shown that iron deficiency cannot be linked to vegetarian diets. Vegetarians can get as much iron as those that eat meat by a choosing a diet high in vegetables like beans, green leafy vegetables and foods high in vitamin C (ascorbic acid).*
2. **“Everyone needs more iron so everyone should take iron supplements daily.”** *Iron deficiency is a problem for some, but most people that eat a healthy, varied diet consume plenty of iron. Iron overload is as dangerous as iron deficiency. Organs and tissues can be damaged if iron concentrations are chronically exceeded. Excess iron can cause liver disease, heart attacks and colon cancer.*
3. **“Spinach will make you strong like Popeye, since it is high in iron.”** *Spinach does contain iron but it also contains oxalic acid which binds with the iron and prevents its absorption, so it is not a good source for iron. It should be noted that when the iron content was first measured (about the time Popeye was created), the scientist Dr. Emil von Wolff misplaced a decimal point in his reported value that lead to an iron value ten times higher than it should be. His error was not noticed until 60 years later and, by then, Popeye was already a well-established character eating spinach to make him stronger.*
4. **“Only old people have iron deficiency anemia.”** *“Old” people are not in a high risk category for iron deficiency anemia. The most common people that have iron deficiency anemia are women of child bearing age, pregnant women, infants and children, and frequent blood donors.*

# Anticipating Student Questions

**(answers to questions students might ask in class)**

1. **“What color is blood *in the body?”*** *Students (and many adults) believe that blood in the body is blue. Blood in the body is always red. The shade of red does vary. In the arteries where the blood is heavily oxygenated it is bright red. In the veins where the blood carries less oxygen it is dark red but looks blue because the skin blocks the transmission of red light and only blue wavelengths pass through. Blood is red due to hemoglobin, which is the reddish iron-containing protein in red blood cells.*
2. **“In lab, iron(II) is readily oxidized to iron(III) when exposed to the oxygen in the air. Why doesn’t oxygen oxidize the iron(II) in blood as it transports it in the body?”** *Iron(II) is readily oxidized to iron(III) in the presence of oxygen. The protein surrounding the iron prevents this from happening. Research shows that the oxidation of Fe+2 to Fe+3 involves an oxygen bridge between two Fe+2 ions. The bulky protein around the heme group in myoglobin prevents the formation of the oxygen bridge and thereby prevents the oxidation of the iron(II). (Hemoglobin consists of four myoglobin-like units.)*

*Myoglobin molecule with oxygen*

*(*[*http://wps.prenhall.com/wps/media/objects/3313/3393071/blb2402.html*](http://wps.prenhall.com/wps/media/objects/3313/3393071/blb2402.html)*)*



*Hemoglobin molecule showing the four myoglobin type units.*

*(*[*https://respiratorycasestudy-7.wikispaces.com/Hemoglobin*](https://respiratorycasestudy-7.wikispaces.com/Hemoglobin)*)*

# Activities

**Labs and Demos**

1. **A simple lab to determine the iron content in foods:** *“*Simple Iron in Food Determination” provides a procedure to determine the iron in raisins, dates, cereal and spinach. The food is heated until ash is left. The ash is added to water and potassium thiocyanate, KSCN, is added. In the presence of iron, KSCN turns reddish. The iron content is determined by comparing the color to a series of color standards. The lab can be found at: <http://dwb4.unl.edu/Chem/CHEM869K/CHEM869KMats/SimpleIronLab.html>.

A similar lab, “Iron in Food”, can be found in the *Chemistry in the Community* textbook: American Chemical Society. *Chemistry in the Community 2nd edition*, Kendall/Hunt Publishing Company: Iowa, 1988; pp 259–260.

1. **Demonstrate the iron content in cereal:** The “Iron in Cereal” demonstration shows that iron-fortified cereals contain elemental iron. There are many procedures for this demonstration. This particular procedure by Flinn Scientific, Inc. provides instructions for two simple demonstrations, as well as providing suggestions for variations on the demonstration. It also provides suggestions for class discussions. (<https://www.flinnsci.com/iron-in-cereal/dc91603/>)

**Media**

1. **Video about elemental iron:** This video, “Iron” (6:01), by the University of Nottingham describes the characteristics of iron and provides a wide range of interesting facts about iron. (<http://www.periodicvideos.com/videos/026.htm>)
2. **Video describes oxygen in hemoglobin:** “Red Blood Cells and Oxygen” is a short video (1:08) that shows blood cells flowing through capillaries and describes how oxygen is attached to hemoglobin in the lungs and then distributed elsewhere in the body. (<https://www.youtube.com/watch?v=UhqcB34AwpU>)
3. **Video explaining how oxygen and carbon dioxide interact with hemoglobin:** This Khan Academy video, “Hemoglobin Moves O2 and CO2” (14:57) is a detailed video graphically explaining how oxygen moves from the lungs to the tissues and how carbon dioxide is removed from tissue and sent to the lungs. (<https://www.youtube.com/watch?v=QP8ImP6NCk8>)
4. **Video explaining the role iron plays in the body:** “Iron Physiology” (14:06) by Armando Hasudungan graphically explains how the body uses iron and describes the process of the body absorbing iron. It includes the description of the oxidation states that iron undergoes in the body and how the body maintains a certain iron concentration. The video is very detailed, but students would easily understand the contents. (<https://www.youtube.com/watch?v=ahCy97FVUpM>)
5. **Explanation of iron deficiency anemia:** The Khan Academy video “What is Iron Deficiency?” (12:35) explains what iron deficiency anemia is and its causes. (<https://www.youtube.com/watch?v=U1Ls9Vh-3m8>)
6. **Explanation of how to determine oxidation states:** “How to Calculate Oxidation Numbers Introduction” video (13:25) provides a clear explanation of how to determine the oxidation state of elements in compounds. It provides many examples to give students a good understanding of the process. (<https://www.youtube.com/watch?v=-a2ckxhfDjQ>)

**Lessons and Lesson Plans**

1. **Lessons on the science of blood:** This site, “My Blood, Your Blood”, provides a series of lessons that deal with the science of blood. The site includes lesson plans, demonstrations, worksheets with answer sheets, and teacher guides. Part 4 deals with oxygen in the blood. This is appropriate for middle and high school students. (<http://www.americasblood.org/media/43213/mbyb_hs_tg.pdf>)
2. **Lesson plan on hemoglobin:** This lesson, “Hemoglobin”, is designed for advanced chemistry students. Students review chemical concepts by investigating hemoglobin. (<http://www.sas.upenn.edu/~carrolld/LessPlan3Hemoglobin.pdf>)
3. **Lesson to investigate colors of blood:** This lesson, “The Many Colors of Blood”, is based on a *ChemMatters* article with the same title. (Lutz, D. The Many Colors of Blood. *ChemMatters*, 2010, 28(1), pp. 5–7) The students compare the pigments of various types of blood by examining their characteristics such as structure and the atom binding to oxygen. The lesson includes the standards that are addressed, reading guides, activities and teacher instructions. (<https://www.acs.org/content/dam/acsorg/education/resources/highschool/chemmatters/issues/best-of-chemmatters/sample-lesson-plan-the-many-colors-of-blood.pdf>)
4. **Oxidation states:** This provides a simple game for students to practice assigning oxidation states to various elements in compounds. (<https://www.quia.com/pop/31191.html?AP_rand=1756072931>)

**Projects and Extension Activities**

1. **Students keep a food diary:** Students could keep a record of the food they eat for three days. They then could calculate the amount of iron in their diet over that period of time. One source for the iron content in foods can be found here: <http://apjcn.nhri.org.tw/server/info/books-phds/books/foodfacts/html/data/data5e.html>.
2. **Heme iron versus non-heme iron:** Students could investigate the diets containing foods with and without heme iron. They could write a diet plan for a vegetarian, explaining the food choices they select and how that would prevent iron deficiencies.
3. **Iron in cereals:** Students could conducts investigations at home determining the amount of elemental iron in various cereals. A simple description of this project can be found at this website: <http://www.education.com/science-fair/article/iron-in-breakfast-cereal/>.

# References

**(non-Web-based information sources)**

**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 !***

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 “Iron for Breakfast” describes the iron found in cereals. It also discusses the oxidation states of iron and how the body uses iron.

(Schmidt, K. Iron for Breakfast. *ChemMatters*, 1994, *12* (3) pp 13–15)

 The various colors of blood in different animals is investigated and explained by its chemical makeup in this article.

(Lutz, D. The Many Colors of Blood. *ChemMatters*, 2010, *28* (1), pp 5–7)

# Web Sites for Additional Information

**(Web-based information sources)**

**Iron, the element**

This site provides a variety of information about iron. It includes physical and chemical properties, history of iron, the uses and sources of iron, and a video on iron. (<http://www.rsc.org/periodic-table/element/26/iron>)

 Interesting facts about iron as well as some history of the use of iron can be found here: <http://www.livescience.com/29263-iron.html>.

 This site has not only chemical and physical properties of iron but also has a basic video about iron as an element. (<http://www.elementalmatter.info/iron-properties.htm>)

 The process of extracting iron from it ore and the production of steel is described at this site. It also describes various type of iron and steel. (<http://www.chemguide.co.uk/inorganic/extraction/iron.html>)

**Iron in the body**

 This Oregon State University site provides an extensive, easily understood explanation about iron in the body. It includes detailed information on the function of iron in the body, the sources of iron, iron deficiency and iron overload. (<http://lpi.oregonstate.edu/mic/minerals/iron>)

 “Review on Iron and its Importance for Human Health” is an extensive article that includes many references and interesting diagrams. The article includes information on the metabolism of iron, its bioavailability, human requirements for iron, and causes and consequences of iron deficiency and anemia. (<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3999603/>)

 The Iron Disorders Institute website provides concise information on such topics as the need for iron, iron absorption, recommended daily allowance for iron and iron level tests. (<http://www.irondisorders.org/our-need-for-iron/>)

 Iron absorption is the topic of this short article by the same name. It provides a good explanation of iron absorption and its mechanism. (<http://sickle.bwh.harvard.edu/iron_absorption.html>)

 An explanation of iron toxicity and iron overload, as well at the consequences of each, can be found here: <https://authoritynutrition.com/why-too-much-iron-is-harmful/>.

At this site, the “Nutrients and Dietary Energy Calculator” will quickly determine the amount of various nutrients, including iron, a person needs. (<https://www.nrv.gov.au/node/add/nutrients-energy-calc>)

**Polyphenols**

At this site there is a concise article, “Polyphenols - What They Are, and Why You Need Them”**,** discussing what polyphenols are, the various types of polyphenols, their role in plants and humans, and their benefits. There is also a short video describing polyphenols. (<http://articles.mercola.com/sites/articles/archive/2015/12/14/polyphenols-benefits.aspx>)

 “Plant Polyphenols as Dietary Antioxidants in Human Health and Disease” is an extensive article about polyphenols. It includes information about their structure, occurrence, bioavailability, and benefits. It includes many references and graphics as well. (<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2835915/>)

 A short explanation of polyphenols and a description of some of their health benefits are described here: <http://www.globalhealingcenter.com/natural-health/what-are-polyphenols/>.

**Oxidation states**

At this Khan Academy site, titled “Oxidation Numbers”, oxidation states (numbers) are clearly explained, rules are given and examples are provided. (<https://www.khanacademy.org/science/chemistry/chemical-reactions-stoichiome/types-of-chemical-reactions/a/oxidation-number>)

 Rules for assigning oxidation states, an extensive list of examples and practice problems can be found at this University of Waterloo site: <http://www.science.uwaterloo.ca/~cchieh/cact/c123/oxidstat.html>.

 A Khan Academy video, “Oxidation state trends in periodic table”

 (8:37), can be found at this site. It examines the periodic trends in oxidation states. (<https://www.khanacademy.org/science/chemistry/oxidation-reduction/redox-oxidation-reduction/v/oxidation-state-trends-in-periodic-table>)

This site provides a simple game, “Oxidation Numbers”, for students to practice assigning oxidation states to various elements in compounds. (<https://www.quia.com/pop/31191.html?AP_rand=1756072931>)