

# **Life Does not Live by Bread Alone: A Lesson in Micronutrient Deficiencies**

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*Disclaimer: The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the Centers for Disease Control and Prevention.*

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### **Summary**

This lesson is designed for an introductory-level biology course or a food science course. The focus of the lesson is the relationship between micronutrients and the proper metabolic function of plants and humans. This lesson could also be taught as an introductory lesson in biochemistry, nutrition, botany, or ecology. Micronutrients specific to plants and to human metabolic function will be explored through research, observation, and discussion.

### **Learning Outcomes**

- Students will be able to name and identify micronutrients essential to plants and humans.
- Students will be able to explain how specific micronutrients function in plants and in humans.
- Students will be able to associate deficiency of a micronutrient with a specific outcome in plants and humans.
- Students will be able to identify various micronutrient deficiencies in a plant by examining observable symptoms.
- Students will be able to identify various micronutrient deficiencies in humans by evaluating and analyzing a list of symptoms.

### **Materials**

1. Photocopies of “Student Micronutrient Webquest” and “Making Connections Questions” (one copy each per student)
2. Photocopies of “Identify a Plant Micronutrient Deficiency” and “Identify a Human Micronutrient Deficiency” worksheets (one copy per group of four students)
3. Laminated “Plant Micronutrient Deficiency Cards” (one set per group of four students)
4. Laminated “Human Micronutrient Deficiency Cards” (one set per group of four students)
5. Computers with Internet access (one per student)

### **Total Duration**

2 hours and 40 minutes

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## **Procedures**

### **Teacher Preparation**

If necessary, familiarize yourself with specific micronutrients that are important to proper human and plant functioning. These micronutrients should include iodine (I), iron (Fe), folic acid, and vitamin A for humans; and zinc (Zn), manganese (Mn), iron (Fe), and boron (B) for plants. A thorough understanding of how deficiencies of those specific micronutrients affect plants and humans is needed to teach this lesson. For more information, check out web resources such as “IMMPaCt – International Micronutrient Malnutrition Prevention and Control Program,” “Folic Acid: Topic Home,” and “Land and Water Publications Series – Fertilizer and Plant Nutrition Bulletins.”

Photocopy for each student the handouts “Student Micronutrient Webquest” (Step 2) and “Making Connections Questions” (Conclusion). Make one copy for each group of four students of “Identify a Plant Micronutrient Deficiency – Micronutrient Deficiency Cards,” “Identify a Human Micronutrient Deficiency – Micronutrient Deficiency Cards,” “Identify a Plant Micronutrient Deficiency” activity, and “Identify a Human Micronutrient Deficiency” activity (Step 3).

Laminate the sheets from the “Identify a Plant Micronutrient Deficiency – Micronutrient Deficiency Cards” and cut the cards along the dotted lines. Do the same for “Identify a Human Micronutrient Deficiency – Micronutrient Deficiency Cards.” The laminated cards can be used again.

Reserve a computer lab (one computer per student). If a computer is not available for each student, students can work in small groups.

### **Web Resources**

Title: IMMPaCt

– International Micronutrient Malnutrition Prevention and Control Program.

URL: [www.cdc.gov/nccdphp/dnpa/impact/index.htm](http://www.cdc.gov/nccdphp/dnpa/impact/index.htm)

Description: This website from the Centers for Disease Control and Prevention provides micronutrient deficiency information as it pertains to human populations.

Title: Folic Acid: Topic Home

URL: [www.cdc.gov/ncbddd/folicacid/index.htm](http://www.cdc.gov/ncbddd/folicacid/index.htm)

Description: This website from the Centers for Disease Control and Prevention provides information on folic acid.

Title: Land and Water Publications Series – Fertilizer and Plant Nutrition Bulletins (Bulletin 7 – Micronutrients)

URL: <ftp://ftp.fao.org/agl/agll/docs/fpnb7.pdf>

Description: This document from the United Nations’ Food and Agriculture Organization provides micronutrient deficiency information as it pertains to plant populations.

### **Introduction**

**Duration: 20 minutes**

Introduce the topic by asking the students to compare and contrast a picture of a healthy plant and a plant with a micronutrient deficiency. These pictures are found on the website “Essential Elements for Plant Growth – Sulfur.” Ask the following questions to engage the class in a discussion:

- What is the definition of micronutrient deficiency?  
(A lack or shortage of a substance, such as a vitamin or mineral, that is essential in minute amounts for the proper growth and metabolism of a living organism).
- What might have caused a micronutrient deficiency in this plant?  
(The soil does not contain enough of the micronutrient to adequately supply the plant).
- It is evident from the pictures that micronutrient deficiencies occur in plants; however, they can also occur in humans. What might be some of the more prevalent micronutrient deficiencies in the United States and around the world?  
(U.S. – iron, calcium, folic acid; Global – iron, vitamin A, folic acid, iodine)<sup>1</sup>

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<sup>1</sup> Office of Dietary Supplements, National Institutes of Health. Dietary Supplement Fact Sheets [online]. 2006. [cited 2006 Aug 21]. Available from URL: [http://dietary-supplements.info.nih.gov/Health\\_Information/Information\\_About\\_Individual\\_Dietary\\_Supplements.aspx](http://dietary-supplements.info.nih.gov/Health_Information/Information_About_Individual_Dietary_Supplements.aspx)

- What would you like to know about micronutrient deficiencies in humans?  
(Answers will vary)

To view more pictures of micronutrient-deficient plants, go to the “Micronutrient Nutrition in Plants” website and click the “next page” button at the bottom of the webpage to continue to the next image. There are 11 pictures.

### **Web Resources**

Title: Essential Elements for Plant Growth – Sulfur

URL: [www.soils.wisc.edu/courses/soils326/sulfur.htm](http://www.soils.wisc.edu/courses/soils326/sulfur.htm)

Description: This University of Wisconsin website provides an image of a healthy and a sulfur deficient plant.

Title: Micronutrient Nutrition in Plants

URL: [www.soils.wisc.edu/courses/soils326/deficien.htm](http://www.soils.wisc.edu/courses/soils326/deficien.htm).

Description: This University of Wisconsin website provides pictures of plants with specific micronutrient deficiencies. Note: Use the “next” button at the bottom of each webpage to continue to the next image.

## **Step 2**

**Duration: 1 hour and 30 minutes**

To help students better understand the effects of micronutrient deficiencies in plants and humans, have them conduct research using the Internet. Give each student a copy of the “Student Micronutrient Webquest” worksheet to be completed individually in the computer lab. Students will use information gathered from the “IMMPaCt,” “Folic Acid,” “Dietary Supplement Fact Sheet,” “UNICEF: Bringing Science to Bear”, and “Land and Water Publications” web resources to fill out the worksheet.

### **Web Resources**

Title: IMMPaCt – International Micronutrient Malnutrition Prevention and Control

URL: [www.cdc.gov/nccdphp/dnpa/impact/index.htm](http://www.cdc.gov/nccdphp/dnpa/impact/index.htm)

Description: This website from the Centers for Disease Control and Prevention provides micronutrient deficiency information as it pertains to human populations.

Title: Folic Acid: Topic Home

URL: [www.cdc.gov/ncbddd/folicacid/index.htm](http://www.cdc.gov/ncbddd/folicacid/index.htm)

Description: This website from the Centers for Disease Control and Prevention provides information on folic acid.

Title: Dietary Supplement Fact Sheet

URL: [http://dietary-supplements.info.nih.gov/Health\\_Information/Information\\_About\\_Individual\\_Dietary\\_Supplements.aspx](http://dietary-supplements.info.nih.gov/Health_Information/Information_About_Individual_Dietary_Supplements.aspx)

Description: This National Institutes of Health website provides detailed information on micronutrients and micronutrient deficiencies in humans.

Title: UNICEF: Bringing Science to Bear

URL: <http://www.unicef.org/sowc98/sowc98c.pdf>

Description: This UNICEF website provides detailed information on micronutrients and micronutrient deficiencies in humans.

Title: Land and Water Publications Series – Fertilizer and Plant Nutrition Bulletins (Bullet 7 – Micronutrients)

URL: <ftp://ftp.fao.org/agl/agll/docs/fpnb7.pdf>

Description: This document from the United Nations' Food and Agriculture Organization provides micronutrient deficiency information pertaining to plant populations.

### **Supplemental Documents**

Title: Student Micronutrient Webquest

Description: This document contains questions on micronutrient deficiencies and how they relate to malnutrition. It includes tables to be completed by the student to link micronutrients with their role in proper functioning and to identify possible outcomes of deficiencies for both plants and humans.

Title: Student Micronutrient Webquest Answer Key

Description: This document contains the correct answers for the Student Micronutrient Webquest worksheet.

### **Step 3**

**Duration: 20 minutes**

After the introductory activities and Webquest, students should have a basic understanding of micronutrients. Students should be able to associate micronutrient deficiencies with impaired function of an organism.

In this step, students will apply their research in the “Identify a Plant Micronutrient Deficiency” and “Identify a Human Micronutrient Deficiency” activities. Divide students into groups of four and give each group one plant card from “Identify a Plant Micronutrient Deficiency – Micronutrient Deficiency Cards” and one human card from “Identify a Human Micronutrient Deficiency – Micronutrient Deficiency Cards.” Using the signs and symptoms listed on the cards, along with the information acquired from the “Student Micronutrient Deficiency Webquest” research, students will deduce the micronutrient that is deficient in the plant and human described on each card. Students will then fill out the “Identify a Plant Micronutrient Deficiency” and the “Identify a Human Micronutrient Deficiency” worksheets. If time allows, students can get more than one plant or human deficiency card and identify other micronutrient deficiencies.

### **Web Resources**

Title: Micronutrient Nutrition in Plants

URL: [www.soils.wisc.edu/courses/soils326/deficien.htm](http://www.soils.wisc.edu/courses/soils326/deficien.htm)

Description: This University of Wisconsin website shows plants with specific micronutrient deficiencies.

Title: Land and Water Publications (Fertilizer and Plant Nutrition Bulletins Bullet 7 – Micronutrients)

URL: <ftp://ftp.fao.org/agl/agll/docs/fpnb7.pdf>

Description: This document from the United Nations' Food and Agriculture Organization provides extensive information about plant micronutrients and symptoms of micronutrient deficiencies.

Title: IMMPaCt – International Micronutrient Malnutrition Prevention and Control Program.

URL: [www.cdc.gov/nccdphp/dnpa/impact/index.htm](http://www.cdc.gov/nccdphp/dnpa/impact/index.htm)

Description: This website from the Centers for Disease Control and Prevention provides micronutrient deficiency information pertaining to human populations.

Title: Folic Acid: Topic Home

URL: [www.cdc.gov/ncbddd/folicacid/index.htm](http://www.cdc.gov/ncbddd/folicacid/index.htm)

Description: This website from the Centers for Disease Control and Prevention provides information on folic acid.

### **Supplemental Documents**

Title: Identify a Plant Micronutrient Deficiency – Micronutrient Deficiency Cards

Description: This document provides the template for the plant micronutrient deficiency cards.

Title: Identify a Plant Micronutrient Deficiency Worksheet

Description: This worksheet directs students to analyze one plant micronutrient card and identify the deficient nutrient.

Title: Identify a Plant Micronutrient Deficiency Answer Key

Description: This document provides the correct answers to the questions asked in the “Identify a Plant Deficiency” worksheet.

Title: Identify a Human Micronutrient Deficiency – Micronutrient Deficiency Cards

Description: This document provides the template for the human micronutrient deficiency cards.

Title: Identify a Human Micronutrient Deficiency Worksheet

Description: This worksheet directs students to analyze one human micronutrient card and identify the deficient nutrient.

Title: Identify a Human Micronutrient Deficiency Answer Key

Description: This document provides the correct answers to the questions asked in the “Identify a Human Deficiency” worksheet.

### **Conclusion**

**Duration: 50 minutes**

After student groups have predicted their plant and human micronutrient deficiencies, have each student complete “Making Connections Questions.” By answering these questions, students will make connections between micronutrient deficiencies and metabolic function in plants and humans.

### **Supplemental Documents**

Title: Making Connections Questions

Description: This document helps students summarize what they have learned about micronutrient deficiencies from the lesson by asking a series of short-answer questions.

Title: Making Connections Questions Answer Key

Description: The document provides the correct answers to “Making Connections Questions.”

## **Assessment**

Students will be evaluated using the “Student Micronutrient Webquest” (Step 2), the “Identify a Plant Micronutrient Deficiency” activity (Step 3), the “Identify a Human Micronutrient Deficiency” activity (Step 3), and the “Making Connections Questions” (Conclusion).

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## **Modifications**

### **Extensions**

Using the information collected in the data table from the “Student Micronutrient Webquest,” students can choose a micronutrient to study in-depth. Students should search for certain populations where the selected micronutrient deficiency is common. Students should then search the Internet to identify projects underway to address the problem. Students should describe the project(s) in detail. The “IMMPaCt – International Micronutrient Malnutrition Prevention and Control Program” website is a useful tool for this extension.

Students can design an ecological poster or advertisement illustrating the connections between soils, plants, and animals in terms of nutrient cycling. Students should then speculate the consequences to the cycle if important micronutrients are missing.

Students can design a public service announcement (PSA) on the importance of micronutrients. Multiple PSAs can be made using different media sources (e.g., television, brochures, radio) to reach various demographics. Emphasis can be put on comparing the consequences of micronutrient-poor diets to the benefits of micronutrient-rich diets, thereby emphasizing the importance of a micronutrient-sufficient diet to one’s overall health.

### **Web Resource**

Title: IMMPaCt – International Micronutrient Malnutrition Prevention and Control Program.

URL: [www.cdc.gov/nccdphp/dnpa/impact/index.htm](http://www.cdc.gov/nccdphp/dnpa/impact/index.htm)

Description: This website from the Centers for Disease Control and Prevention provides micronutrient deficiency information pertaining to the global human population.

### **Other Modifications**

This lesson plan can be modified to better suit younger students and/or students with special needs. A reduction in the number of micronutrients researched would allow the student to learn and participate without being overwhelmed with material.

This lesson plan can also be modified for higher-level students in biology II or advanced placement biology. Students can lead their peers in designing and conducting their own wet lab investigation of plant micronutrients.

Students can also compare the protein structure of the plant pigment chlorophyll and the animal pigment hemoglobin. Students would identify any similarities and/or differences in protein structure and function. Students would then investigate if the micronutrients have any influence on the proteins’ structure and function.

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## Education Standards

### **National Science Education Standards**

#### SCIENCE AS INQUIRY, CONTENT STANDARD A:

As a result of activities in grades 9–12, all students should develop

- **Abilities necessary to do scientific inquiry**
- Understandings about scientific inquiry

#### LIFE SCIENCE, CONTENT STANDARD C:

As a result of their activities in grades 9–12, all students should develop understanding of

- The cell
- Molecular basis of heredity
- Biological evolution
- **Interdependence of organisms**
- **Matter, energy, and organization in living systems**
- Behavior of organisms

#### EARTH AND SPACE SCIENCE, CONTENT STANDARD D:

As a result of their activities in grades 9–12, all students should develop an understanding of

- Energy in the earth system
- **Geochemical cycles**
- Origin and evolution of the earth system
- Origin and evolution of the universe

#### HISTORY AND NATURE OF SCIENCE, CONTENT STANDARD G:

As a result of activities in grades 9–12, all students should develop understanding of

- Science as a human endeavor
- **Nature of scientific knowledge**
- Historical perspectives

### **New York State MST Education Standards (Math, Science, and Technology)**

#### STANDARD #1: Analysis, Inquiry, and Design

The central purpose of scientific inquiry is to develop explanations of natural phenomena in a continuing, creative process

Students:

- **Hone ideas through reasoning, library research, and discussion with others, including experts**

#### SCIENCE STANDARD #4: Science Standard

Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science.

Key Idea #5: Organisms maintain a dynamic equilibrium that sustains life.

Students:

- **Explain the basic biochemical processes in living organisms and their importance in maintaining dynamic equilibrium**
- **Explain disease as a failure of homeostasis**

Key Idea #6: Plants and animals depend on each other and their physical environment.

Students:

- **Explain factors that limit growth of individuals and populations.**

## **Student Micronutrient Webquest**

Life Does Not Live by Bread Alone  
Kathie Fuller and Judy Jones, CDC's 2006 Science Ambassador Program

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

Class: \_\_\_\_\_

We have been discussing the impact of micronutrient deficiencies on plants and humans. Micronutrients are important for the synthesis of enzymes, hormones, and tissues in all organisms. An organism would not function properly without micronutrients. Micronutrient deficiencies can play a large role in malnutrition. Answer the following questions to better understand the meaning of micronutrient malnutrition.

**Directions:** Use the following websites to complete the questions and Table 1.

- Center for Disease Control and Prevention's (CDC) IMMPaCt – International Micronutrient Malnutrition Prevention and Control Program: [www.cdc.gov/nccdphp/dnpa/impact/index.htm](http://www.cdc.gov/nccdphp/dnpa/impact/index.htm)
- CDC's Folic Acid website: [www.cdc.gov/ncbddd/folicacid/index.htm](http://www.cdc.gov/ncbddd/folicacid/index.htm)
- National Institutes of Health's (NIH) Dietary Supplement Fact Sheet: [http://dietary-supplements.info.nih.gov/Health\\_Information/Information\\_About\\_Individual\\_Dietary\\_Supplements.aspx](http://dietary-supplements.info.nih.gov/Health_Information/Information_About_Individual_Dietary_Supplements.aspx)

1. **What is micronutrient malnutrition?**

2. **List several adverse effects of micronutrient deficiencies in humans.**

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3. **What are some of the cost-effective public health interventions that have helped relieve micronutrient malnutrition?**

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4. Complete Table 1 to show how each micronutrient is related to proper metabolic function and provide an outcome of its deficiency.

Table 1: Micronutrients in humans

| <b>Micronutrients Important in Humans</b> | <b>Function</b> | <b>Outcome of Micronutrient Deficiency</b> |
|---|-----------------|--|
| <b>Iodine (I)</b>                         |                 |  |
| <b>Iron (Fe)</b>                          |                 |  |
| <b>Folic acid</b>                         |                 |  |
| <b>Vitamin A</b>                          |                 |  |

**Directions:** Use the following document found online to complete Table 2:  
<http://ftp.fao.org/aql/aqll/docs/fpnb7.pdf>. The page numbers that are associated with each micronutrient are listed in the table.

**Table 2: Micronutrients in plants**

| <b>Micronutrients<br/>Important in Plants</b>                            | <b>Function</b> | <b>Outcome of Micronutrient<br/>Deficiency</b> |
|--|-----------------|--|
| <p style="text-align: center;"><b>Iron (Fe)</b><br/>Pages 32–33</p>      |                 |  |
| <p style="text-align: center;"><b>Zinc (Zn)</b><br/>Pages 13–15</p>      |                 |  |
| <p style="text-align: center;"><b>Manganese (Mn)</b><br/>Pages 43–44</p> |                 |  |
| <p style="text-align: center;"><b>Boron (B)</b><br/>Pages 65–66</p>      |                 |  |

## **Student Micronutrient Webquest Answer Key**

Life Does Not Live by Bread Alone  
Kathie Fuller and Judy Jones, CDC's 2006 Science Ambassador Program

We have been discussing, in detail, the impact of micronutrient deficiencies on plants and humans. Micronutrients are important for the synthesis of enzymes, hormones, and tissues in all organisms. An organism would not function properly without micronutrients. Micronutrient deficiencies can play a large role in malnutrition. Answer the following questions to better understand the meaning of micronutrient malnutrition.

**Directions:** Use the following websites to complete the questions and Table 1.

- Center for Disease Control and Prevention's (CDC) IMMPaCt – International Micronutrient Malnutrition Prevention and Control Program: [www.cdc.gov/nccdphp/dnpa/impact/index.htm](http://www.cdc.gov/nccdphp/dnpa/impact/index.htm)
- CDC's Folic Acid website: [www.cdc.gov/ncbddd/folicacid/index.htm](http://www.cdc.gov/ncbddd/folicacid/index.htm)
- National Institutes of Health's (NIH) Dietary Supplement Fact Sheet: [http://dietary-supplements.info.nih.gov/Health\\_Information/Information\\_About\\_Individual\\_Dietary\\_Supplements.aspx](http://dietary-supplements.info.nih.gov/Health_Information/Information_About_Individual_Dietary_Supplements.aspx)
- UNICEF. Bringing science to bear: <http://www.unicef.org/sowc98/sowc98c.pdf>.

1. What is micronutrient malnutrition?

**According to the Centers for Disease Control and Prevention, micronutrient malnutrition is a shortage of one or more vitamins or minerals. (1)**

2. List several adverse effects of micronutrient deficiencies in humans.

**According to the Centers for Disease Control and Prevention, micronutrient deficiencies can adversely affect humans in some of the following ways (1):**

- **Child survival and growth**
- **Women's health and pregnancy outcome**
- **Brain development and I.Q. of a population**
- **Educational achievement**
- **Adult productivity**
- **Resistance to illness**

3. What are some of the cost-effective public health interventions that have helped relieve micronutrient malnutrition?

**According to the Centers for Disease Control and Prevention, there are several cost-effective interventions that have been implemented to improve micronutrient malnutrition, including (1):**

- **Improving the variety and quality of foods available (known as food diversification)**
- **Adding vitamins or minerals to foods (called fortification)**
- **Providing high-risk individuals with supplementary vitamins and minerals**

- **Reducing the rate of common infections and parasitic diseases**

4. Complete Table 1 to show how each micronutrient is related to proper metabolic function and provide an outcome of its deficiency.

**Table 1: Micronutrients in humans**

| <b>Micronutrients Important in Humans</b> | <b>Function</b>  | <b>Outcomes of Micronutrient Deficiency</b>  |
|---|--|--|
| <b>Iodine (I)</b>                         | Iodine is required for the production of the thyroid hormone. Iodine is needed for proper fetal brain development (2).   | According to CDC, iodine deficiency can cause severe mental and physical retardation, known as cretinism. Iodine deficiency in the chronic form, can cause goiter (a disorder characterized by swelling of the thyroid gland) in both adults and children (1).   |
| <b>Iron (Fe)</b>                          | According to NIH, iron is an essential part of proteins involved in oxygen transport. Iron is essential for the regulation of cell growth and differentiation (3).               | According to CDC, iron deficiency impairs the cognitive development of children through to adolescence. Iron deficiency damages immune mechanisms and is associated with increased morbidity rates. It can also impair physical work capacity in men and women by up to 30% (1). According to NIH, iron deficiency anemia can lead to individuals' feeling tired or weak, having a decreased work capacity, and a decreased immune function (3). |
| <b>Folic Acid (Folate)</b>                | According to CDC, folic acid is a B vitamin that is used in our bodies to make new cells (4).  | According to CDC, if a woman does not have enough folic acid in her body before and while she is pregnant, her baby is more likely to have a major birth defect of the brain or spine (4).   |
| <b>Vitamin A</b>                          | According to NIH, vitamin A plays an important role in vision, bone growth, reproduction, cell division, and cell differentiation. It also helps regulate the immune system (3). | According to NIH, vitamin A deficiency contributes to blindness by making the cornea very dry and damaging the retina and cornea. It can also lower the body's ability to fight infections (3).  |

**Directions:** Use the following document found online to complete Table 2: <ftp://ftp.fao.org/aql/aqll/docs/fpnb7.pdf>. The page numbers that are associated with each micronutrient are listed in the table.

**Table 2: Micronutrients in plants**

| <b>Micronutrients Important in Plants</b>    | <b>Function</b>   | <b>Outcomes of Micronutrient Deficiency</b>  |
|--|---|--|
| <p><b>Iron (Fe)</b><br/>Pages 32–33</p>      | <p>According to FAO, iron is important in the formation of several plant enzyme systems including catalases, peroxidases, and cytochromes. Although iron is not a component of the chlorophyll molecule, synthesis of chlorophyll would not occur without it (5).</p>                 | <p>According to FAO, iron deficiency in plants causes chlorosis, or leaf yellowing, especially in the interveinal regions of new leaves. Increased iron deficiency results in an increase of chlorosis in the leaf, stunted growth, and in severe cases, death (5).</p>              |
| <p><b>Zinc (Zn)</b><br/>Pages 13–15</p>      | <p>According to FAO, zinc is the metal component of many enzymes such as carbonic anhydrase and several dehydrogenases. Zinc is also involved in RNA synthesis as well as the production of the hormone auxin, which stimulates the elongation of cells in developing shoots (5).</p> | <p>According to FAO, leaves appear light green with yellow or bleached spots in the interveinal regions of the leaves. Both root and stem growth may be stunted (5).</p>   |
| <p><b>Manganese (Mn)</b><br/>Pages 43–44</p> | <p>According to FAO, manganese activates a number of enzymes. Without manganese, the splitting of water molecules during photosynthesis would not occur (5).</p>  | <p>According to FAO, manganese deficiency is initially indicated by changes in leaf coloration. Leaves display alternating dark green and pale green color banding patterns. Eventually the pale green bands turn gray or white. Foliage thins as foliage-bearing twigs die (5).</p> |
| <p><b>Boron (B)</b><br/>Pages 65–66</p>      | <p>According to FAO, boron is required for the normal development and differentiation of tissues in plants. Boron increases the stability of cell walls and is involved in the reproductive cycle (5).</p>  | <p>According to FAO, boron deficiency appears in young leaves. It stunts terminal growth resulting in a bushy plant appearance. Leaves are misshapen, wrinkled, and take on a dark blue hue (5).</p>   |

**References:**

- Centers for Disease Control and Prevention. IMMPaCt – International Micronutrient Malnutrition Prevention and Control Program: Micronutrient Facts. 2006. [cited 2006 Aug 21]. Available at URL: <http://www.cdc.gov/nccdphp/dnpa/impact/index.htm>.

2. UNICEF. Bringing science to bear [online]. [cited 2006 August 18]. Available from URL: <http://www.unicef.org/sowc98/sowc98c.pdf>.
3. Office of Dietary Supplements, National Institutes of Health. Dietary Supplement Fact Sheets [online]. 2006. [cited 2006 Aug 21]. Available from URL: [http://dietary-supplements.info.nih.gov/Health\\_Information/Information\\_About\\_Individual\\_Dietary\\_Supplements.aspx](http://dietary-supplements.info.nih.gov/Health_Information/Information_About_Individual_Dietary_Supplements.aspx).
4. Centers for Disease Control and Prevention. Folic Acid. 2006. [cited 2006 Sept 15]. Available at URL: <http://www.cdc.gov/ncbddd/folicacid/basics.htm>.
5. Katyal JC, Randhawa AS. Micronutrients. FAO Fertilizer and Plant Nutrition Bulletin. 1983;7:1–83. Available from URL: <ftp://ftp.fao.org/aql/aqll/docs/fpn7.pdf>.

**Identify a Plant Micronutrient Deficiency**  
**Micronutrient Deficiency Cards**

Life Does Not Live by Bread Alone  
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According to the Food and Agriculture Organization,

- Young leaves are misshapen, wrinkled and often take on a bluish hue.

Reference:

Katyal JC, Randhawa AS.  
Micronutrients. FAO Fertilizer and Plant Nutrition Bulletin. 1983;7:1–83.

Available from URL:

<ftp://ftp.fao.org/agl/agll/docs/fpnb7.pdf>.

**Micronutrient Deficiency Card #1**

According to the Food and Agriculture Organization,

- Leaves develop alternate light and dark green banding.
- Foliage thins and twigs die back.

Reference:

Katyal JC, Randhawa AS.  
Micronutrients. FAO Fertilizer and Plant Nutrition Bulletin. 1983;7:1–83.

Available from URL:

<ftp://ftp.fao.org/agl/agll/docs/fpnb7.pdf>.

**Micronutrient Deficiency Card #2**

According to the Food and Agriculture Organization,

- Interveinal chlorosis\* evident in leaves.
- Both stem and root growth stunted.

\*Chlorosis is a yellowing of the leaves

Reference:

Katyal JC, Randhawa AS.  
Micronutrients. FAO Fertilizer and Plant Nutrition Bulletin. 1983;7:1–83.

Available from URL:

<ftp://ftp.fao.org/agl/agll/docs/fpnb7.pdf>.

**Micronutrient Deficiency Card #3**

According to the Food and Agriculture Organization,

- Interveinal chlorosis\* evident in leaves.
- Entire leaf may become papery white.

\*Chlorosis is a yellowing of the leaves

Reference:

Katyal JC, Randhawa AS.  
Micronutrients. FAO Fertilizer and Plant Nutrition Bulletin. 1983;7:1–83. Available from URL:

Available from URL:

<ftp://ftp.fao.org/agl/agll/docs/fpnb7.pdf>.

**Micronutrient Deficiency Card #4**

## **Identify a Plant Micronutrient Deficiency**

Life Does Not Live by Bread Alone  
Kathie Fuller and Judy Jones, CDC's 2006 Science Ambassador Program

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

Class: \_\_\_\_\_

Micronutrient deficiencies adversely affect the proper functioning in both plants and humans. These nutrients, although needed in small amounts, are essential to growth, reproduction, and many other processes in plants and humans.

### **Directions**

1. Get one "Identify a Plant Micronutrient Deficiency – Micronutrient Deficiency Card" for your group.
2. Carefully read and consider the listed symptoms on the card. Based on the evidence provided by these symptoms and what you learned in your plant micronutrient Webquest research, please identify the specific plant micronutrient deficiency.

### **Observations and Analysis**

**Plant Photo Card #:** \_\_\_\_\_

List several visual symptoms shown by the plant:

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Identify the micronutrient deficiency: \_\_\_\_\_

## Identify a Plant Micronutrient Deficiency Answer Key

Life Does Not Live by Bread Alone  
Kathie Fuller and Judy Jones, 2006 CDC Science Ambassador Program

Micronutrient deficiencies adversely affect the proper functioning in both plants and humans. These nutrients, although needed in small amounts, are essential to growth, reproduction, and many other processes in plants and humans.

### **Directions**

1. Get one "Identify a Plant Micronutrient Deficiency- Micronutrient Deficiency Card" for your group.
2. Carefully read and consider the listed symptoms on the card. Based on the evidence provided by these symptoms and what you learned in your plant micronutrient Webquest research, please identify the specific plant micronutrient deficiency.

### **Observations and Analysis**

#### **Plant Photo Card #: 1**

List several visual symptoms shown by the plant:

- **Misshapen leaves**
- **Bluish hue evident**
- **Wrinkling in young leaves (1)**

Identify the micronutrient deficiency: **Boron (B)**

#### **Plant Photo Card #: 2**

List several visual symptoms shown by the plant:

- **Leaf very chlorotic and light in color**
- **Dark green banding**
- **Leaves thinning (1)**

Identify the micronutrient deficiency: **Manganese (Mn)**

#### **Plant Photo Card #: 3**

List several visual symptoms shown by the plant:

- **Leaf interveinal chlorosis**
- **Stem and root growth stunted (1)**

Identify the micronutrient deficiency: **Zinc (Zn)**

#### **Plant Photo Card #4**

List several visual symptoms shown by the plant:

- **Leaf interveinal chlorosis**
- **Some leaves so chlorotic they appear white (1)**

Identify the micronutrient deficiency: **Iron (Fe)**

### **Reference:**

1. Katyal JC, Randhawa AS. Micronutrients. FAO Fertilizer and Plant Nutrition Bulletin. 1983;7:1–83. Available from URL: <ftp://ftp.fao.org/aql/aqll/docs/fpn7.pdf>.

**Identify a Human Micronutrient Deficiency**  
**Micronutrient Deficiency Cards**

Life Does Not Live by Bread Alone  
Kathie Fuller and Judy Jones, CDC's 2006 Science Ambassador Program

According to CDC, deficiency of this micronutrient in humans leads to:

- Impairment in the cognitive development of young children
- Decreased immune function
- Anemia

Reference:

<http://www.cdc.gov/nccdphp/dnpa/immact/index.htm>

**Micronutrient Deficiency Card #1**

According to CDC, deficiency of this micronutrient in humans leads to:

- Defects in fetal brain development
- Severe mental and physical retardation
- Cretinism

Reference:

<http://www.cdc.gov/nccdphp/dnpa/immact/index.htm>

**Micronutrient Deficiency Card #2**

According to CDC, deficiency of this micronutrient in humans leads to:

- Decreased immune function
- Blindness
- Increased morbidity in populations

Reference:

<http://www.cdc.gov/nccdpdp/dnpa/immact/index.htm>

**Micronutrient Deficiency Card #3**

According to CDC, deficiency of this micronutrient in humans leads to:

- Increased risk for birth defects of the brain and spine

Reference:

<http://www.cdc.gov/ncbddd/folicacid/index.htm>

**Micronutrient Deficiency Card #4**

## **Identify a Human Micronutrient Deficiency**

Life Does Not Live by Bread Alone  
Kathie Fuller and Judy Jones, CDC's 2006 Science Ambassador Program

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

Class: \_\_\_\_\_

Micronutrient deficiencies adversely affect the proper functioning in both plants and humans. These nutrients, although needed in small amounts, are essential to growth, reproduction, and many other processes in the organism.

### **Directions**

1. Get one "Identify a Human Micronutrient Deficiency – Micronutrient Deficiency Card" for your group.
2. Carefully read and consider the listed symptoms on the human micronutrient deficiency card. Based on the evidence provided by these symptoms and what you learned in your human micronutrient Webquest research, please identify the human micronutrient deficiency.

### **Observations and Analysis**

**Human Micronutrient Deficiency Card #:** \_\_\_\_\_

List the symptoms shown on your card:

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Identify the micronutrient deficiency: \_\_\_\_\_

## Identify a Human Micronutrient Deficiency Answer Key

Life Does Not Live by Bread Alone  
Kathie Fuller and Judy Jones, 2006 CDC Science Ambassador Program

Micronutrient deficiencies adversely affect the proper functioning in both plants and humans. These nutrients, although needed in small amounts, are essential to growth, reproduction, and many other processes in the organism.

### **Directions**

1. Get one "Identify a Human Micronutrient Deficiency- Micronutrient Deficiency Card" for your group.
2. Carefully read and consider the listed symptoms on the human micronutrient deficiency card. Based on the evidence provided by these symptoms and what you learned in your human micronutrient Webquest research, please identify the human micronutrient deficiency.

### **Observations and Analysis**

#### **Human Micronutrient Deficiency Card #1**

List the symptoms shown on your card.

- **Impairment in the cognitive development of young children**
- **Decreased immune function**
- **Anemia (1)**

Identify the micronutrient deficiency: **Iron (Fe)**

#### **Human Micronutrient Deficiency Card #2**

List the symptoms shown on your card.

- **Defects in fetal brain development**
- **Severe mental and physical retardation**
- **Cretinism (1)**

Identify the micronutrient deficiency: **Iodine (I)**

#### **Human Micronutrient Deficiency Card #3**

List the symptoms shown on your card.

- **Decreased immune function**
- **Blindness**
- **Increased morbidity in populations (1)**

Identify the micronutrient deficiency: **Vitamin A**

#### **Human Micronutrient Deficiency Card #4**

List the symptoms shown on your card.

- **Increased risk for birth defects of the brain and spine (2)**

Identify the micronutrient deficiency: **Folic Acid**

### **References:**

1. Centers for Disease Control and Prevention. IMMPaCt – International Micronutrient Malnutrition Prevention and Control Program: Micronutrient Facts. 2006. [cited 2006 Aug 21]. Available at URL: <http://www.cdc.gov/nccdphp/dnpa/impact/index.htm>.
2. Centers for Disease Control and Prevention. Folic Acid. 2006. [cited 2006 Sept 15]. Available at URL: <http://www.cdc.gov/ncbddd/folicacid/basics.htm>.

## **Making Connections Questions**

Life Does Not Live by Bread Alone  
Kathie Fuller and Judy Jones, CDC's 2006 Science Ambassador Program

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

Class: \_\_\_\_\_

**Directions:** Answer the questions that follow.

1. Plant micronutrients appear extremely important in the biosynthesis of \_\_\_\_\_ involved in metabolic pathways. (Hint: Draw from the Function column of your Webquest research).
  2. \_\_\_\_\_, \_\_\_\_\_, and \_\_\_\_\_ are three important plant micronutrients we have been discussing.
  3. We have been talking about how micronutrient deficiencies can affect a plant on an "individual" scale. Think now about what effects micronutrient deficiencies in plants might have on a global scale. If several important food staples (like corn or wheat) had a widespread micronutrient deficiency, and farmers did not have a large crop, what would happen to local and global food reserves? What do you think the impact might be on humans?
- 
4. Using the Function column of your Webquest research, which human micronutrient appears particularly important during the fetal stage of development?
  5. Using the micronutrient you identified in question #4, explain why this micronutrient is needed during fetal development.
  6. \_\_\_\_\_ is especially important during childhood for cognitive development. It is also needed throughout the lifespan.
  7. Identify a food product that has a micronutrient added to it. Be sure to name the food as well as the micronutrient.
  8. True or False: Micronutrients are essential for life. (Circle your choice)
  9. What is your favorite food? If you were allowed to eat only this food, do you think you might be deficient in some micronutrients over time? Based on your answer, speculate why people are encouraged to eat a diet that has a lot of variety (e.g., fruits, vegetables, whole grains, meats).

## **Making Connections Questions Answer Key**

Life Does Not Live by Bread Alone  
Kathie Fuller and Judy Jones, CDC's 2006 Science Ambassador Program

Directions: Answer the questions that follow.

1. Plant micronutrients appear extremely important in the biosynthesis of **enzymes** involved in metabolic pathways. (Hint: draw from the Function column of your Webquest research).
2. **Iron, zinc, and manganese** are three important plant micronutrients we have been discussing. **Accept all other reasonable answers.**
3. We have been talking about how micronutrient deficiencies can affect a plant on an 'individual' scale. Think now about what effects micronutrient deficiencies in plants might have on a global scale. If several important food staples (like corn or wheat) had a widespread micronutrient deficiency, and farmers did not have a large crop, what would happen to local and global food reserves? What do you think the impact might be on humans?

**Answers could vary but might include:**

**Because plant yields are reduced, global and local food reserves would be reduced or lowered. This might mean that people would need to rely on another food source or they might have to set certain limits (or ration) the amount available.**

4. Using the Function column of your Webquest research, which human micronutrient appears particularly important during the fetal stage of development?  
**Iodine or folic acid**
5. Using the micronutrient you identified in question #4, explain why this micronutrient is needed during fetal development.  
**Iodine: Iodine is needed for proper fetal brain development. (1)**

**Folic acid: According to CDC, folic acid is a B vitamin that is used in our bodies to make new cells. If a woman does not have enough folic acid in her body before and while she is pregnant, her baby is more likely to have a major birth defect of the brain or spine. (2)**

6. This micronutrient is especially important during childhood for cognitive development. It is also needed throughout the lifespan.  
**Iron**
7. Identify a food product that has a micronutrient added to it. Be sure to name the food as well as the micronutrient.

**Possible answers could include:**

| <b>Food:</b>          | <b>Micronutrient(s) added:</b>         |
|-----------------------|--|
| Cereal grain products | Folic acid, other B vitamins, and iron |

|             |                                  |
|-------------|----------------------------------|
| Milk        | Vitamin D, Vitamin A, riboflavin |
| Salt        | Iodine                           |
| Some juices | Calcium                          |

8. **True** or False: Micronutrients are essential for life. (Circle your choice)
9. What is your favorite food? If you were allowed to eat only this food, do you think you might be deficient in some micronutrients over time? Based on your answer, speculate why people are encouraged to eat a diet that has a lot of variety (e.g., fruits, vegetables, whole grains, meats).

**Answers will vary. A possible answer might include:  
My favorite food is chocolate. If I ate only chocolate for a long period of time, I may become deficient in several micronutrients. People are encouraged to eat a diet with a lot of variety to make sure they are getting adequate nutrition, like making sure they have enough micronutrients.**

**References:**

1. UNICEF. Bringing science to bear [online]. [cited 2006 August 18]. Available from URL: <http://www.unicef.org/sowc98/sowc98c.pdf>.
2. Centers for Disease Control and Prevention. Folic Acid. 2006. [cited 2006 Sept 15]. Available from URL: <http://www.cdc.gov/ncbddd/folicacid/basics.htm>.