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MIDDLE GRADES

Using STEM to Investigate Issues in FOOD PRODUCTION

Integrated activities that cultivate an interest in **science**, **technology**, **engineering**, and **mathematics** and encourage students to explore careers in these fields

SUPPORTS NCTM STANDARDS

State, National, & Provincial CORRELATED Standards

SUPPORTS NSE STANDARDS

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Using STEM to Investigate Issues in Food Production

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Introduction to the Series

The *STEMs of Learning: Science, Technology, Engineering, and Mathematics* is an initiative designed to get students interested in these career fields. In 2009, the National Academy of Engineering (NAE) and the National Research Council (NRC) reported that there is a lack of focus on the science, technology, engineering, and mathematics (STEM) subjects in K–12 schools. This creates concerns about the competitiveness of the United States in the global market and the development of a workforce with the knowledge and skills needed to address technical and technological issues. The focus of many current STEM education programs is on mathematics and science and not on engineering and technology. This series was developed to encourage students to become a part of the solution and increase interest in the STEM areas. The series introduces students to the use of STEM skills to solve problems. It is our hope that through these investigations students will become interested in the STEM areas of study.

The *Using STEM to Investigate Series* provides fun and meaningful integrated activities that cultivate an interest in topics in the STEM fields of science, technology, engineering, and mathematics and encourages students to explore careers in these fields. The series introduces students to the following topics: Issues in Alternative Energy, Issues in Food Production, and Issues in Managing Waste using science, mathematics, engineering, and technological design as a means for problem solving and scientific inquiry. Students actively engage in solving real-world problems using scientific inquiry, content knowledge, and technological design. All of the activities are aligned with the National Science Education Standards (NSES), the National Council of Teachers of Mathematics (NCTM) Standards, and the International Technology Education Association (ITEA) Standards for Technological Literacy. For correlations to state, national, and Canadian provincial standards, visit www.carsondellosa.com.

The series is written for classroom teachers, parents, families, and students. The books in this series can be used as a full unit of study or as individual lessons to supplement existing curriculum programs or textbooks. Activities are designed to be pedagogically sound, hands-on minds-on activities that support the national standards. Parents and students can use this series as an enhancement to what is done in the classroom or as a tutorial at home. The procedures and content background are clearly explained in the introduction and within the individual activities. Materials used are commonly found in classrooms and homes or can be ordered from science supply sources.

Science, Technology, and Society

Science, technology, and society are very closely related. Science and technology have impacted personal and community health, population growth, natural resources, and environmental quality. It is important for students to understand the interrelationship of science, technology, and society because

Introduction to *Using STEM to Investigate Issues in Food Production* (cont.)

these factors impact their daily lives all over the world. Science advances new technology, and using new technology increases scientific knowledge.

Science and technology are pursued for different reasons. Science inquiry is driven by the desire to understand the natural world. Technology is driven by the need to solve problems and meet human needs. Technology usually has more of a direct effect on society. For example, the creation of the telephone, computers, and the Internet have had a large impact on the way our society communicates. Science and technology have also impacted the diagnoses and treatment of diseases that have increased the longevity of the human race. Science and technology have created more comfortable places for us to live in most areas of the world. However, science and technology have also had a negative impact on our environment. As a new technology that we need or want is developed, the impact on the environment must be closely examined.

The National Science Education Standards (NSES) unifying concepts and science processes skills integrate the areas of science, technology, engineering, and mathematics (STEM). The unifying concepts include systems, order, and organization; evidence, models, and explanations; change, constancy, and measurement; evolution and equilibrium; and form and function. The processes of inquiry are skills used in all content areas and in our everyday lives to investigate and solve problems. These science process skills include the basic skills of classifying, observing, measuring, inferring, communicating, predicting, manipulating materials, replicating, using numbers, developing vocabulary, questioning, and using cues. The integrated science process skills include creating models, formulating a hypothesis, generalizing, identifying and controlling variables, defining operationally, recording and interpreting data, making decisions, and experimenting. See the Appendix for a list of skills and definitions.

Technological Design Process

The NSES recommend that students have abilities and understandings of technological design and about science and technology. The NSES Science and Technology Content Standard E states that the technological design process includes identifying a problem or design opportunity; proposing designs and possible solutions; implementing the solution; evaluating the solution and its consequences; and communicating the problem, processes, and solution. Creativity, imagination, and a good content background are necessary in working in science and engineering. The process is a continuous cycle.

The International Technology Education Association (ITEA) Standards for Technological Literacy also suggest that students develop abilities for a technological world that include applying the design process to solve a problem, using and maintaining technological products, and assessing the impact of the products on the environment and society. Students should have an understanding of the attributes of design and engineering design and the role of troubleshooting, research and development, inventions and innovations, and experimentation in problem solving. The design process includes identifying and collecting information about everyday problems that can be solved by technology. It also includes generating ideas and requirements for solving the problems. See the Appendix for a list of skills and definitions.

Introduction to *Using STEM to Investigate Issues in Food Production* (cont.)

Mathematical Problem Solving

The National Council of Teachers of Mathematics (NCTM) recommends that students develop abilities to use problem-solving skills, formulate problems, develop and apply a variety of strategies to solve problems, verify and interpret results, and generalize solutions and strategies to new problems. Students also need to be able to communicate with models, orally, in writing, and with pictures and graphs; reflect and clarify their own thinking; use the skills of reading, listening, and observing to interpret and evaluate ideas; and be able to make conjectures and convincing arguments. Students should be able to recognize and apply reasoning processes, make and evaluate arguments, validate their own thinking, and use the power of reasoning to solve problems. All of these skills are related to science and technology, as well as mathematics. See the Appendix for a list of skills and definitions.

Introduction to Food Production

Food production in the world has reached a crisis level. The population of the world is growing, and food production, processing, preservation, and distribution are not keeping up with the population growth. The impact of food production on the health and welfare of society and the environment needs to be investigated to resolve this crisis. The cause of this food crisis is greatly debated. Agricultural engineers and scientists are working to solve the problems related to how to produce, preserve, process, and distribute food to all people in a safe and effective way with little negative impact on the environment.

There are two sides to the food production issue. One side encourages local food and sustainability. The other side believes that food production should be as efficient and as productive as possible. Food prices should be kept low and adequate reserves for bad crop years should be maintained. U.S. farmers are trying to balance sustainable farm practices with higher productivity.

Eric Holt-Gimenéz suggests the root cause of the food crisis is the global food system. The global food system is the sum of all global interactions among food, agriculture, water, energy, soil, and humans that comprise our food system. The global food system is vulnerable to the economic and environmental impact of international grain traders, corporations (seed, chemical, and fertilizer processors), and global market chains. In order to resolve the food crisis, the food system needs to be fixed. Some areas of concern include: government support of domestic food production and stabilizing fair prices to farmers, workers, and consumers; the halt of agrofuel expansion and the re-regulatation of the financial sector investment in food commodities; the return to small family farms and locally based approaches to food production and food system management; and finally, creating a social change in the way food is managed. This means reducing the political influence of large corporations and strengthening antitrust laws and enforcement of these laws.

Introduction to *Using STEM to Investigate Issues in Food Production* (cont.)

Some believe the only way to feed a growing population is by genetically modified crops and the use of chemical pesticides and fertilizers. However, newer scientific studies recommend sustainable farming as a better way. The U.S. Working Group on the Food Crisis report *Can Sustainable Agriculture Feed the World?* recommends that an investment should be made in sustainable agriculture. Sustainable agriculture or agroecology (the science of sustainable agriculture) combines scientific methods with local farming knowledge to create diverse and productive food production systems without relying on expensive seeds and chemicals. International assessments done by the International Assessment of Agricultural Knowledge, Science and Technology for Development in 2008 indicated that conventional industrial agriculture degrades soils and other natural resources and threatens water, energy resources, and the global climate. A United Nations Environment Program confirmed their findings. Both studies encourage the development of sustainable food production.

The following trends are hot topics in food production. Organic farming doubled from 2000 to 2007. Organic farming typically avoids the use of chemical and genetically modified organisms. It relies on ecological processes rather than chemical fertilizers, pesticides, and herbicides. Genetically modified crops were produced on 114.3 million hectares or 282.3 million acres in 2007. Genetically modified crops have been modified through genetic engineering, which eliminates, alters, or introduces new genetic elements, including from one unrelated species to another. In 2008, grain production rose to 2.287 billion tons. From 1993 to 2008, the amount of land used for grain has remained steady at 700 million hectares, but crop yields are up 146% over the last 46 years. All stages of the food system—seeds, farming, processing, preserving—are being consolidated into a few corporate firms. In 2009, 1.02 billion people in the world were undernourished or suffered from chronic hunger, which is an increase of 12% since 2008. One in six people in the world suffer from undernourishment. Undernourishment means people are receiving less than 1,800 kilocalories (kcal) a day compared to the 3,400 kcal per day in the United States, Canada, and Europe. In 2009, the world population went over 6.8 billion. It is projected the population will be 9.4 billion by 2050. Meat production increased to 280 million tons in 2008 and has doubled since the mid 1970s, with more than half of the meat and dairy products being produced in developing nations. Fish production—wild and farmed in aquaculture—increased to 158 million tons in 2008. Aquaculture is the most rapidly growing area in food production. In 2007, 80% of fish stocks were fully used or overused.

All of the current trends in food production require an examination of the overall world food system from seed to table. All of these reports recommend developing a sustainable food production system. This book on food production examines the issues of producing food for a growing population while trying not to have a negative impact on consumers or the environment.

Chapter One: Food Production Issues

Teacher Information

Topic: Issues in food production

Standards:
NSES – Unifying Concepts and Processes
Systems, Order, and Organization
Form and Function

NSES – Content
NSES A: Science as Inquiry
NSES B: Physical Science
NSES C: Life Science
NSES D: Earth and Space
NSES E: Science and Technology
NSES F: Personal and Social Perspectives
NSES G: Science as a Human Endeavor

NCTM:
Problem Solving
Communication
Reasoning
Mathematical Connections
Probability

ITEA:
Nature of Technology
Technology and Society
Technological World

Concepts:
Food production
Issues in food production, i.e., need for production of food; sustainable development; policies; organic gardening; green food production; food processing; food distribution; amount of land and water resources that are productive; population growth; livestock production; transportation of food; impact on the environment; chemical herbicides, pesticides, and fertilizers; etc.

Objectives:
Students will be able to…
- Examine their own beliefs and values to make decisions related to food production.
- Debate the issues, respecting the rights of others to maintain different rights and values.
- Evaluate possible solutions to food production issues.
- Explain what needs to be considered when making decisions about managing food production.

Activity – Food Production Issue Discussion Sheets (p. 6–12)

Materials:
Issue Discussion Sheets

TEACHER NOTE: The major purpose of this activity is to help students learn about the issues involved in food production. Prior to starting, the teacher should discuss the rules for discussion (i.e., all students have the right to their own opinions, they will listen to and respect each other's ideas, etc.). Reproduce the number of sets of sheets needed for groups of four students. Each group should have a set.

Chapter One: Food Production Issues

Student Information

Topic: Issues in food production

Concepts:
Food production
Issues in food production, i.e., need for production of food; sustainable development; policies; organic gardening; green food production; food processing; food distribution; amount of land and water resources that are productive; population growth; livestock production; transportation of food; impact on the environment; chemical herbicides, pesticides, and fertilizers; etc.

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Content Background:

Over 6.8 billion people live on Earth, with some 7 million people being born every month. By 2012, over 7 billion people will be sharing the same land, water, and air. It is difficult for the planet to support this many people, and as a result, over 925 million people live in chronic hunger, which means that they never get enough food to eat.

Food scientists struggle to increase the amount of food produced. There are two sides to the food production issue. One side believes that every food production system should be as efficient and as productive as possible. It should keep the food prices low and maintain adequate reserves for bad crop years. Some believe the

only way to feed a growing population is with genetically modified crops that produce more grain while using chemical pesticides and fertilizers to increase output. Some people believe giving artificial growth hormones and antibiotics to animals will produce more and better meat.

The other side of the food production debate encourages local food and sustainability. Newer scientific studies recommend sustainable farming as a better way. The U.S. Working Group on the Food Crisis report *Can Sustainable Agriculture Feed the World?* recommends that an investment should be made in sustainable agriculture.

Sustainable agriculture or **agroecology** (the science of sustainable agriculture) combines scientific methods with local farming knowledge to create diverse and productive food production systems without relying on expensive seeds and chemicals. Modern agriculture, using current science, technology, and engineering, has allowed more food to be grown and more fresh foods distributed all over the world. However, the current methods used in commercial agriculture are not a sustainable system.

International assessments done by the International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD) in 2008 indicated that conventional

Chapter One: Food Production Issues

Student Information

industrial agriculture degrades soils and other natural resources and threatens water, energy resources, and the global climate. A United Nations Environment Program confirmed their findings. Both studies encourage the development of sustainable food production.

Agricultural engineers identify, investigate, and solve problems related to food and livestock production. Issues related to food production include land and water use; kinds of farming; food distribution; food processing; food safety and preservation; politics and money; a growing population; and food production sustainability.

U.S. farmers are trying to balance sustainable farm practices with higher productivity. Those involved in U.S. crop production have given increased attention to the impact of farming on the environment due to new technology, chemicals, and seed development. Kinds of farming practices such as organic, chemical, crop rotation, small farms, and industrialized farms are all major issues in food production.

The amount of usable land and water on Earth is very small. Earth has a surface area of 51 billion hectares (2.47 acres in one hectare). This is the amount of land that provides food, water, and other resources. If you look at a globe, 28% of the surface is land and the other 72% is water. Of the 28% that is land, 19% is biologically productive; the other 9% is only marginally productive or unproductive.

Land is **biologically productive** if it is fertile enough to support agriculture, forests, or animal life. The marginally productive or unproductive land includes pavement, land covered by ice, land that has no water, or land that has unsuitable soil conditions for plant growth.

Of the 72% of Earth's surface lakes and oceans, only 4% is biologically productive for human use. The other 68% is marginally productive or unproductive water. The productivity may be reduced by destruction of coral reefs, oil spills, overfishing, and shoreline development.

Of the 51 billion hectares of surface area including land and water, only about 23% is biologically productive. This is the only area we have to produce our food, materials, and energy, and to absorb our wastes. We also share this area with 10 million other species.

Recent changes in global weather patterns have brought new challenges to food production. Desertification is one challenge. **Desertification** is the erosion of formerly productive land into deserts. The most famous example of desertification in the United States was the Dust Bowl in the 1930s. Due to poor farming techniques and a long drought, much of the land in Kansas, Oklahoma, and Texas literally blew away. Today, desertification is causing the Sahara desert to expand south across Africa at a rate of 48 km per year. This land goes from being biologically productive to unproductive.

When more land is cleared for farming by removing trees and bushes, the topsoil blows or washes away, causing a need for more chemicals to be added to add necessary nutrients. If land is used over and over for the same crops, all of the nutrients in the soil disappear. One way to avoid this is by adding chemical fertilizers. However,

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chemical fertilizers, pesticides, and herbicides are getting into our lakes, streams, rivers, and other water resources from groundwater contamination around fields and in the runoff from fields.

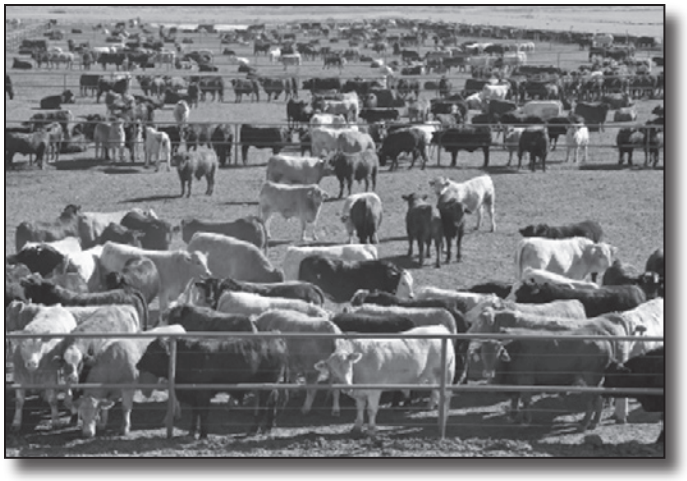
A **food system** includes all of the steps in food production from farm to table. The food is grown, shipped, processed, shipped again to markets, purchased in stores, transported home by consumers, and eaten. The energy needed includes not just the energy related to growing the food but also for transportation, processing, preserving, planting, and harvesting.

More food is needed to support the increasing population of the world. Some of the solutions to this food shortage are to use more land, add either organic or chemical fertilizers to marginally productive land to enrich the soil, use chemical herbicides and pesticides to increase crop production, and use genetically engineered crops. Small local farms are being replaced by large corporate farms in an effort to produce more food.

To meet the meat needs required by so many people, large livestock confinements are used to produce more meat. In these lots, livestock are sometimes given antibiotics to reduce the chances of infections and hormones to increase growth or milk production. There is some evidence now that these antibiotics and hormones are getting into the human food supply.

Bringing in food from other countries creates new problems. Farmers in other countries may not use the same standards that the United States requires. For example, Brazil uses chemicals that are banned in the U.S. and the European Union because they are harmful to the environment and humans.

Some believe that returning to local organic farms is the best way to get the best foods to the people and support local economies. Organic farming minimizes the use of synthetic fertilizers and pesticides, which reduces agricultural pollution and reduces the amount of chemicals consumers ingest. Organic farming also uses less fossil fuels and more locally available resources, making it better for the planet. Organic farming doesn't use genetically modified crops, but instead uses local varieties.



One possible solution to the food production problem is the use of hydroponics. **Hydroponics** refers to plants growing without any kind of soil. Plants can grow in other mediums. Some of these mediums include water with nutritional substances added, husks of coconuts, gravel, or mineral wool.

Soil contains nutrients that plants need to grow and provides support to the roots and plant. When it rains, these nutrients are dissolved in water and carried to the plant through the roots. The type of soil and the amount of nutrients in the soil determine how much of the nutrients the plants can absorb and how well it grows.

In hydroponics, nutrients can be dissolved in water and directly absorbed into the roots. The amount of nutrients can be formulated so that the plant can always take in exactly the nutrients that it needs to grow.

Food preservation and processing are an important part of food production. **Food processing and preservation** means the processes by

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which raw food is made suitable for cooking, eating, storing, marketing, and extending their shelf life. In areas where crops cannot be grown year around, there has to be some way to store food to use during the winter months when food cannot be grown.

Historically, fish and meats were dried or salted to preserve them. Louis Pasteur developed the pasteurization process for wine and milk, which killed the organisms that caused foods to spoil. In the 19th and 20th centuries, food preservation was done by heating and sealing foods in jars or cans and by freezing foods to keep them from spoiling.

Food distribution is one of the major issues in food production. **Food distribution** includes local and regional food systems, food miles, energy costs, transportation, oil, etc. One problem in the distribution of food is that not all crops can be grown in all areas, so the only food available in an area are the foods that can be grown in that area. For example, oranges cannot be grown in colder climates.

Since not all food is grown locally, some food is transported from other parts of the world. Ways of preserving food for extended periods of time and carrying it through different temperatures needed to be developed. One way to preserve the food longer and make it easier to transport is by processing the food before it is shipped. Food processing can be done by heating, freezing, pasteurizing, and adding chemical preservatives.

The processing and preservation of foods helps improve food safety. However, it creates other problems in the food system and for the environment. It requires more natural resources such as water, fossil fuels, and land. Packaging and processing food creates more problems with waste management. These packaging materials break down slowly, and the chemicals from these packages and preservation processes can become highly concentrated in our water, air, and soil.

A **sustainable food system** protects or enhances biodiversity, enriches soil, and protects water quality. If the natural systems that provide humans with oxygen, soil, the absorption of carbon dioxide, clean water, and biodiversity are destroyed, the earth will not support life. A sustainable food system avoids using man-made chemicals that stay in the environment longer than a few days.

Man-made substances and chemicals are not easily broken down by natural Earth cycles. They sometimes accumulate in the environment and damage the air, water, and soil. A sustainable food system should not use a lot of plastic packaging, which comes from fossil fuels, or it should develop a way to recycle all packaging.

A sustainable food system must feed all people. It should not feed one community at the expense of others. Resources should be distributed more evenly to all people. Currently, some groups of people around the world are starving while other groups of people are becoming obese because of an overabundance of food. A sustainable food system should use resources efficiently and recycle or reuse wastes.

This book will explore how to develop a sustainable food system to feed the growing population of the world.

Name: _____ Date: _____

Chapter One: Food Production Issues

Student Activity

Activity – Issues in Food Production

Materials:

Issue Discussion Sheets

Challenge Question: What are some of the issues related to food production?

Procedure:

1. Divide the class into groups of four and give each group a set of issue discussion sheets.
2. One person in the group takes an issue sheet, reads it to the group, and explains the decision they have chosen and why they have made that decision.
3. The other members of the group then share whether they agree or disagree and why they agree or disagree.
4. This continues until all of the issues are discussed in the small groups.

Challenge:

On your own paper, develop a food system that solves some of the problems identified in this activity.

Name: _____ Date: _____

Chapter One: Food Production Issues

Food Production Issue Discussion Sheets

Issue 1 – Farming

Modern industrial agricultural practices are economically productive but are not sustainable. Some think the practices used by industrial agriculture threaten the biological systems necessary for life. These practices have caused topsoil erosion, loss of fertility, arable land losses, and losses to insect pests that become immune to the widely used pesticides.

More food is needed. Possible solutions include using more land; add either organic or chemical fertilizers, herbicides, and pesticides to marginally productive land; and use genetically engineered seeds.

To solve the meat shortage, large livestock confinements are used to quickly produce more meat. Some livestock are given antibiotics to reduce the chances of infections and hormones to increase growth or milk production. There is some evidence now that these antibiotics and hormones are getting into the human food supply.

Some believe that returning to local organic farms is the best way to get the best foods to the people and support local economies.

Question: There is a shortage of food in the world. What should be done?

a. Clear more trees from land for farming.

b. Use a local approach to food production, and raise the food close to where it will be consumed.

c. Reduce the need for antibiotics by allowing livestock to be outside in fields where they can get fresh air and exercise.

d. Try to find a balance of using some chemicals, genetic engineering, and organic farming.

e. Do something else. Explain.