The world we live in has been shaped in many important ways by human action. We have created technological options to prevent, eliminate, or lessen threats to life and the environment and to fulfill social needs. We have dammed rivers and cleared forests, made new materials and machines, covered vast areas with cities and highways, and decided—sometimes willy-nilly—the fate of many other living things.

In a sense, then, many parts of our world are designed—shaped and controlled, largely through the use of technology—in light of what we take our interests to be. We have brought the earth to a point where our future well-being will depend heavily on how we develop and use and restrict technology. In turn, that will depend heavily on how well we understand the workings of technology and the social, cultural, economic, and ecological systems within which we live.

Science for All Americans

Here the focus is on particular technological systems, such as agriculture and manufacturing, and the benchmarks indicate what particular engineering, scientific, social, and historical understandings students should gain. In the companion Chapter 3: The Nature of Technology, the benchmarks deal with general principles of technology and engineering, with the relationships between technology and science, and with the effects of technology on society.

The sections in this chapter are not intended to cover all major areas of technology. Other areas—such as the technology of warfare, transportation, or architecture—might also have been included. The areas covered here should supply an ample sampling of major ideas to serve as a basis for understanding various key technologies of today—and those that will come tomorrow. For many of the ideas in this chapter, students will need a background understanding of the physical setting and the living environment, for which benchmarks are given in Chapter 4: The Physical Setting and Chapter 5: The Living Environment.

The content should not be taught solely in the technology curriculum. The responsibility needs to be shared by science, mathematics, social studies, and history. Some of the instruction can be didactic but much of it should be done through student projects. Technology projects should be part of the curriculum from the earliest grades, gradually becoming longer and more complex. Most projects should be done by small student

groups with teachers acting as advisers. Classroom visits by people involved in technology-related fields—such as architecture, transportation, and textiles—may help to acquaint students with occupational opportunities in technology.

A. Agriculture

A majority of people never see food or fiber before those products get to retail stores, and primary-school children may have only vague ideas about where their foods and fabrics come from. So the first steps in teaching children about agriculture are to acquaint them with basics: what grows where, what is required to grow and harvest it, how it gets to the stores, and how modern-day U.S. agriculture compares with agriculture in other places and other times. Such comparisons prepare students to consider how agriculture can be improved, what resources are needed, and the consequences for society and the environment.

For most students, media resources about agricultural production in the United States and elsewhere may have to supplement firsthand experiences. Projects to trace locally available food and fiber back to their origins are helpful in providing at least some personal experience. As students become better able to handle complexity, they can undertake projects that require planting, fertilizing, selecting desirable features, and adjusting the amount of light, water, and warmth.

Projects for older students can involve the preservation of food and fiber, requirements for good nutrition, comparing energy efficiency of different products, and long-term changes in water, soil, and forest resources. They should expand their sense of what agriculture is to include the planting and harvesting of materials for use as fibers and fuel and for building shelters. When students are able to grasp the interdependent elements of the agricultural system, including fuel, roads, communications, weather, and prices, they may assess what disasters do to an agricultural system and possible ways of recovering or even reducing their likelihood.

Kindergarten through Grade 2

The basic experiences for primary-school children include seeing plants grow from seeds they have planted, eating the edible portions of the mature plants, and noticing

what plants and other things animals eat. Comparisons can be made to see what happens if some plants don't get water or light, but carefully controlled experiments should be delayed until later, when students will know better how to conduct scientific investigations. Some of the earliest stories to be read to and by small children can tell about life on the farm and what happens to food between the farm and the store.

By the end of the 2nd grade, students should know that

- Most food comes from farms either directly as crops or as the animals that eat the crops. 8A/P1a
- To grow well, plants need enough warmth, light, and water. Crops must be protected from weeds and pests. 8A/P1bc
- Part of a crop may be lost to pests or spoilage. 8A/P2
- A crop that is fine when harvested may spoil before it gets to consumers. 8A/P3
- Machines improve what people get from crops by helping in planting and harvesting. 8A/P4a
- Machines keep food fresh by packaging and cooling and move the food long distances from where it is grown to where people live. 8A/P4b*

Grades 3 through 5

Students should enhance their earlier experiences by following plants through the production of new seeds and offspring. They can design experiments to see the effects of water, light, and fertilizer, although their experiments should involve only one variable at a time.

They should study what crops are found in different environments, including oceans,

and trace the paths that various foods and fibers take as they move from growers to consumers. Storage, transportation, preservation, processing, and packaging should be considered. Where possible, students should visit markets, farms, grain elevators, and processing plants and examine trucks, trains, cargo planes, and as many other parts of the "technological food chain" as possible.

To appreciate the rigors of agriculture, students should learn about life in earlier times and the great effort that went into planting, nurturing, harvesting, and using crops. It is important that they know some of the hazards that food encounters from the time it is a seed until it reaches the kitchen. Food preservation and sanitation can be explored in early grades, but explanation of spoilage as the result of microorganisms should wait until 6th through 8th grades.

By the end of the 5th grade, students should know that

- Some plant varieties and animal breeds have more desirable characteristics than others, but some may be more difficult or costly to grow. 8A/E1a

- The kinds of crops that can grow in an area depend on the climate and soil. 8A/E1b

- Irrigation and fertilizers can help crops grow in places where there is too little water or the soil is poor. 8A/E1c

- Damage to crops by rodents, weeds, or insects can be reduced by using poisons, but their use may harm other plants or animals. 8A/E2*

- Heating, salting, smoking, drying, cooling, and air-tight packaging are ways to slow down the spoiling of food by microscopic organisms so food can be stored longer before being used. 8A/E3*

- Modern technology has increased the efficiency of agriculture so that fewer people are needed to work on farms than ever before. 8A/E4

- Places too cold or dry to grow certain crops can obtain food from places with more suitable climates. Much of the food eaten by Americans comes from other parts of the country and the world. 8A/E5

Grades 6 through 8

In middle school, students can examine how changes in climate, fashion, or ecosystems affect agriculture. The news media, even in the cities, often report how well particular crops are doing in response to weather, pestilence, market demand, federal policies, and the like. Students' discussions of such current events can lead them to raise technological, scientific, economic, and political questions for further study.

Students should continue to be engaged in gardening and experimentation. As an addition to traditional seeds-in-soil activities, hydroponics is an inexpensive and relatively rapid way to help students understand modern agriculture because it allows them to monitor and control many of the variables that contribute to plant growth and development. Students at this level also study geography and the early history of the human species, including the transformation from hunting and gathering to farming. This agricultural revolution provides a dramatic instance of social change made possible by technological advances and, conversely, of technological advance promoted by social change.

By the end of the 8th grade, students should know that

- Early in human history, people changed from hunting and gathering to farming. This shift allowed changes in the division of labor between men and women and between children and adults and led to the development of new patterns of government. 8A/M1

- People control some characteristics of plants and animals they raise by selective breeding and by preserving varieties of seeds (old and new) to use if growing conditions change. 8A/M2*

- In agriculture, as in all technologies, there are always trade-offs to be made. Specializing in one crop may risk disaster if changes in weather or increases in pest populations wipe out that crop. Also, the soil may be exhausted of some nutrients, which can be replenished by rotating the right crops. 8A/M3acd

- Getting food from many different places makes people less dependent on weather in any one place yet more dependent on transportation and communication among far-flung markets. 8A/M3b

- With improved technology, only a small fraction of workers in the U.S. actually plant and harvest the products that people use. Most workers are engaged in processing, packaging, transporting, and selling what is produced. 8A/M4*

Grades 9 through 12

Students' understanding of agricultural technology can increasingly draw upon their understanding of underlying science concerning the interaction of living things with their environments in ecosystems, the inheritance of traits, mutations, and natural selection. Their growing familiarity with systems concepts should be exploited in agricultural contexts to study the interactions among production, preservation, transportation, communications, government regulations, subsidies, and world markets. Social side-effects and tradeoffs of agricultural strategies should be discussed in both local and world contexts.

By the end of the 12th grade, students should know that

- New varieties of farm plants and animals have been engineered by manipulating their genetic instructions to produce new characteristics. 8A/H1

- Government sometimes intervenes in matching agricultural supply to demand to ensure a stable, high-quality, and inexpensive food supply. Regulations are often also designed to protect farmers from abrupt changes in farming conditions and from competition from other countries. 8A/H2

- Agricultural technology requires trade-offs between increased production and environmental harm and between efficient production and social values. 8A/H3a

In the 1900s, agricultural technology led to a huge shift of population from farms to cities and to a great change in how people live and work. 8A/H3b