How are things invented or discovered? Do people just stumble upon new discoveries? Sometimes they do. More often, however, discoveries are made through well-thought-out research that can involve years of work.

What has research done for you and agriculture? Research has altered our world in big ways. The standard of living we enjoy today is much higher than it was for previous generations. New discoveries will continue to be made, and it is expected that future generations will have even higher living standards.

It is estimated that the amount of knowledge humans possess doubles in less than seven months. In other words, in less than seven months from the time you read this, our society will have twice as much knowledge of the world around us as it has today. This new scientific knowledge will be applied to technologies, which are the outcomes and applications of scientific concepts and principles.

In agriculture, scientists actively seek to discover procedures that will increase livestock and crop yields, improve farmland productivity, reduce loss due to disease and insects, develop more efficient equipment, and increase overall food quality. Researchers look for ways to increase farmers’ profits and to protect the environment. Consumers pay less for their food and fiber products, which allows them to spend their money on other things.

Objective:

List ways in which agricultural research is important.

Key Terms:

animal immunization
artificial insemination
biological control
Some Risks Exist

Among the benefits of scientific advancement lie some risks. Scientists and society must consider the potential of research, as well as the risks. With every discovery, there exists some risk. It is up to society, policy makers, and scientists to determine how much risk is acceptable.

Risk comes in many forms. For example, there may be economic loss if the time and money invested in a research project does not result in a useful product. Management of pests might become more difficult through the intense use of pesticides or antibiotics that can cause the selection of more resistant strains of pathogens and insects. Production agriculture has become more specialized and is carried out on a larger scale than ever before. Thus, large corporate farms become more profitable than family farms.

Another side effect of scientific progress is a change in the distribution of the population. As stated, technological advancements have greatly increased the efficiency of food and fiber production methods. With greater efficiency, fewer people are needed to produce food and fiber. In a relatively short period, the United States has gone from a country with the majority of people living and working on farms to a country with less than 2 percent of the population working on farms. Many rural people have relocated to urban areas for employment opportunities.

Some people fear that genetically engineered organisms produced through research could have harmful effects. One concern is that genes of genetically modified species might “escape” from domestication and alter wildlife gene pools. Another is that “super pests” might evolve that are resistant to pest management efforts.

Finding ways through genetic engineering to feed an ever-increasing world population is a topic with which a lot of people are struggling. Studies have shown that the current food production levels will not be able to keep pace with the current population growth. Many scien-
tists believe that genetic engineering holds the key to greatly increasing food supplies for the world. Genetic engineering is a volatile public issue. It is likely that public debate will continue regarding genetic engineering research and application.

**Progress Through Research**

Overall, the future of agriculture is bright. Exciting research in plant and animal sciences is in progress. Following are a few examples of agricultural research. Many other types of research are also being conducted. Through the help of agricultural research and continued testing, the standard of living we enjoy today can be expected to improve.

- **Animal immunization**—Historically, diseases have been devastating to livestock production enterprises. The introduction of vaccines and medicines has improved the health of livestock. Animal immunization, the process of giving animals resistance to disease through vaccination or inoculation, has reduced diseases. Animals in a disease-free environment can be raised at a much lower cost to producers, and the savings are passed on to consumers.

- **Artificial insemination**—Superior animals are the products of superior parents. Artificial insemination is the placing of semen in the female reproductive tract by artificial techniques. With the introduction of artificial insemination, the transfer of genes from a superior sire, or male parent, has increased dramatically. Through modern techniques of semen collection, storage, and distribution, almost any producer can have access to the best genes in the industry.

- **Biological control**—Pests greatly reduce agricultural productivity. One means of pest management is biological control. Some methods of pest management through biological control involve predatory insects, bacteria, fungi, and viruses. The introduction of parasitic wasps into the greenhouse environment to control white flies is an example of biological control. The adult wasps lay their eggs on white fly larvae. When the eggs hatch, the wasp larvae devour the white fly larvae. Another example is the use of the bacterium *Bacillus thuringiensis* to control insect pests of field and vegetable crops.

- **Computer technology**—Computers have enabled researchers to perform their...
work more rapidly than ever before. Data that once took days or even weeks to analyze can now be analyzed in seconds. In animal science, the selection of superior sires and dams can be made easily through computerized production records of progeny. Results of feed formulation data can be used to help determine the best mix of feed grains and supplements. In plant science, computers are used to help determine the optimal time for irrigation and the amount of water to be delivered to the crop. They are also used to determine fertility levels and to adjust application rates. Food scientists rely heavily on computers to analyze the chemistry of foods.

**Embryo transfer**
Whereas artificial insemination capitalizes on the genetic attributes of the sire, embryo transfer focuses on the dam, or female parent. Typically, improving herds through the use of superior dams is slow because of the gestation period of the female. **Embryo transfer** is the process of moving embryos from one female, called the donor female, to the reproductive tract of another female, called the recipient female. The appli-
cation of embryo transfer allows the production of many offspring each year from one superior female.

♦ **Genetic engineering**—Breeding practices for plants and animals are being dramatically changed with new discoveries in biotechnology and genetic engineering. Scientists have learned techniques to select and move genetic material from one plant or animal to another. This process, called **genetic engineering**, holds great potential for improving crops and livestock. Desired results can be obtained more quickly than with traditional breeding methods, and there is greater control over what characteristics will be expressed in the offspring. Some goals of genetic engineering include improved nutritional content of the food we eat, faster growth rates of plants and animals, and greater resistance to diseases, insects, herbicides, and environmental stresses.

♦ **Growth and yield regulation**—Researchers in agronomy identify the plant genes regulating processes that limit photosynthesis, nitrogen fixation, and other important metabolic pathways. With that knowledge, they can use genetic engineering to insert genes or to express the desirable genes. The result is more efficient crop plants. Use of plant growth regulators on certain crops is also receiving greater attention. Researchers are looking for ways to develop corn plants with more ears per plant. Growth regulators may also be used on golf courses and lawns to reduce the growth rate of grasses and thus cut down of the frequency of mowing.

♦ **Hydroponics**—**Hydroponics** is the growing of plants with their roots in a medium other than soil. Sometimes, hydroponics is called soilless culture, because soil is not used. Nutrients essential for plant growth and development are dissolved in water, and the solution is delivered directly to the roots in a vari-

![FIGURE 5. One goal of genetic engineering is to improve the nutritional content of the food we eat.](image1)

![FIGURE 6. Hydroponics is the growing of plants with their roots in a medium other than soil.](image2)
ety of ways. This technique can provide a year-round supply of fresh vegetables in regions that experience cold weather. Adoption of hydroponics reduces the transportation costs normally required to move fresh vegetables over long distances.

- **Pesticides**—Insects, diseases, and weeds account for substantial losses in crop yields and animal health. Through research, scientists have discovered pesticides that can be used to manage pests. Proper use of pesticides has improved yields from agricultural plants and animals. Research continues to result in more effective pesticides that cause less damage to the environment.

- **Post-harvest physiology**—The life processes and functions of harvested fruits and vegetables are subjects of scientific study. Scientists seek to understand better the processes of ripening and the role hormones play in regulating the processes. Many fruits and vegetables are very perishable and the period during which they can be sold is limited. Fruits that ripen uniformly and can be stored for longer times following harvest are sought. The ultimate goal is to provide the consumer with fruits and vegetables of high quality for longer periods.

- **Precision technologies**—The Global Positioning System (GPS), geographic information systems (GIS), microcomputers, and machinery controllers are precision technologies that have improved the efficiency of farming. Satellites orbiting the earth are connected to a ground receiver in a field or on equipment. The system locates exact points on GIS grid maps to control machinery operations in the field. The technology is particularly useful for applying fertilizer and obtaining harvest data.

- **Tissue culture**—Tissue culture is a very technical form of asexual reproduction. As the name implies, small pieces of plant tissue are cultured, or grown, on an artificial medium under sterile condi-
tions. One advantage to tissue culture is that thousands of identical plants can be produced from a small piece of plant tissue. Tissue culture techniques are also used to grow plant and animal cells that have been genetically modified in the laboratory. Cell culture techniques provide scientists a rapid means of screening genetically modified cells to detect their resistance to diseases, herbicides, or environmental stresses, such as salt accumulation and temperature extremes. Cells that survive the screening can be regenerated into whole plants.

- **Specialized crop production**—Researchers are working on developing crops that are specialized for particular commercial uses. Examples include crops with specific traits, such as high protein, oil, or starch content. Some corn hybrids have been developed specifically for ethanol production. In addition, work is being performed on producing crops with higher nutritional value.

**Summary:**

In agriculture, scientists actively seek to discover procedures that will increase livestock and crop yields, improve farmland productivity, reduce loss due to disease and insects, develop more efficient equipment, and increase overall food quality. Researchers look for ways to increase farmers’ profits and to protect the environment. Animal immunization, artificial insemination, biological control of pests, embryo transfer, genetic engineering, hydroponics, and tissue culture are just a few areas of agricultural research. Through agricultural research, the standard of living we enjoy today can be improved.

**Checking Your Knowledge:**

1. Why is agricultural research important?
2. What are some risks with agricultural research?
3. What are some types of research being conducted in agriculture?
Expanding Your Knowledge:

Predict ways in which agriculture might be different 50 years from now because of research underway today. Compare your predictions with those of your classmates.

Web Links:

- Agricultural Research Service, USDA
  http://www.ars.usda.gov

- National Coalition for Food and Agricultural Research
  http://www.ncfar.org/