

## Lecture 28

# Agriculture, Technology, and the Scientific Revolution

Our existence as a civilization has depended on a series of technologies that provide us with sustenance and surplus. Agriculture, in its broadest sense, refers to a complex interaction of humans with other organisms—plants, animals, insects, and microorganisms—that direct the flow of energy from the sun to the supper table.

The origin of new information in agriculture and horticulture derives from two traditions: empirical and experimental. The roots of empiricism stem from efforts of Neolithic farmers, Hellenic root diggers, medieval peasants, and farmers and gardeners everywhere to obtain practical solutions to problems of crop and livestock production. The accumulated successes and improvements passed orally from parent to child, from artisan to apprentice, have become embedded in human consciousness via legend, craft secrets, and folk wisdom. This information is now stored in tales, almanacs, herbals, and histories and has become part of our common culture. More than practices and skills were involved as improved germplasm was selected and preserved via seed and graft from harvest to harvest and generation to generation. The sum total of these technologies makes up the traditional lore of agriculture and horticulture. It represents a monumental achievement of our forebears—largely unknown and unsung.

The scientific tradition is not as old as the empirical but it is ancient, nevertheless. Its beginnings derive from systematic attempts to discover rational explanations for nature. Science, from the Greek “to know” is in reality a method for accumulation of new information about our universe. The driving imperative is the desire to understand. *If necessity is the mother of invention, curiosity is the mother of science.* The scientific method involves experimentation, systematic rationality, inductive reasoning, and constant reformulation of hypotheses to incorporate new facts. When new explanations of natural phenomena are accepted, they must be considered not as dogma but as tentative approaches to the truth, and subject to change. The process is cumulative and science is alive only when it grows. When any society claims to know the complete truth such that further question is heresy, science dies.

One of the curious phenomena of science is that isolated pieces of information, even if of no immediate relevance or consequence, may have potential value. Thus, the recording of experiments to produce a growing body of knowledge, known as the scientific literature, is a prerequisite for the scientific process. However, the accumulation of information without experimentation leads to a dry scholasticism. The great advances in agriculture originally derived from the accumulation of empirical technology but now derive principally from scientific investigations. Still in many cases, it has been hard to separate the two approaches because they are now intertwined. The original technological revolutions took place in prehistory and antiquity.

### Neolithic Technology

Humans have been hunter-gatherers for 99% of the 2 million years our species has roamed the earth; only in the last 10,000 years have people become agriculturists. The most sweeping technologies change for humans occurred in prehistory: the use of tools, the discovery of fire, and the invention of agriculture.

The beginnings of agriculture were foreshadowed by a tremendous amount of knowledge about plants and animals. For example, early humanity from the beginning depended upon botanical knowledge for existence. They became familiar with literally hundreds of species. They knew how to clear or alter vegetation with fire, sow seed, plant tubers, and protect plants. They laid claim to individual trees and tracts of land, celebrated first-fruit ceremonies, prayed for rain, and petitioned for increased yield and abundant harvest. They spun fibers, wove cloth, made string, cord, baskets, canoes, shields, spears, bows and arrows, and a variety of household utensils. They painted pictures, carved masks, and ritual objects, recited poetry, played musical instruments, sang, chanted, performed dances and memorized legends. They harvested grass seeds, threshed, winnowed, and ground them into flour. They dug roots and tubers. They detoxified poisonous plants for food and extracted poisons to stun fish or kill game. They were familiar with a variety of drug and medicinal plants. They understood the life cycles of plants and knew the seasons of the year. Natural populations were below the carrying capacity of the land, famine and starvation were rare.

The beginnings of agriculture involve a series of inventions involving the domestication of useful plants and animals and their management and culture in order to convert them to useful servants providing food and fiber. Domestication involves two distinct events. One is to identify potentially useful species and the other is to actually transform them into dependable servants. The latter is accomplished by no less than a genetic transformation achieved through selection of genetic variants that intensify desirable traits and eliminate undesirable characteristics. It further involved an entire series of technologies concerned with planting, cultivation, harvest, and storage.

### **Technological Innovation in Antiquity**

The basic techniques of agriculture and horticulture were well established in the ancient cultures we call Antiquity (from 3000 BCE to 500 CE). One of the achievements of Antiquity was the creation a written record of agricultural achievements. It also contained the seeds for the beginnings of what we could called scientific studies. The horticultural achievements include:

1. Basic propagation technology: seed handling, grafting, layerage, and cuttage.
2. Planting and cultivation technology involving plowing seed bed preparation, planting.
3. Irrigation technology including water storage in dams and ponds, channeling of water above and below ground, water lifting technology including shaduf, Archimedes screw, sakiieh (chain of pots).
4. Basic technology of storing agricultural products, granaries, underground storage, cave storage
5. Fertilization and crop rotations.
6. Selection and clonal propagation.
7. Basic development of food technology: fermentation (bread and wine), drying, pickling.
8. Beginnings of protected culture (*specularia*).
9. Development of parks and gardens.

### **Scientific Revolution**

It is often difficult to separate technology and science. Clearly, technology can be improved by empirical method often with little understanding of the basic principles involved. Unknown and unsung individuals are often responsible for technological change. In contrast, organized researchers involved with attempts to understand basic causes and underlying principles now carry out modern science. It involves systematic research, the use of controlled experimental method, establishment and testing of hypothesis, and rearranging hypothesis on the basis of results. The development of science for the improvement of agriculture is truly a 20th century phenomenon.

The scientific revolution in science has affected all of agriculture. Here we will consider mechanical, chemical, biological, and informational revolutions in agriculture and horticulture. As in all things involving agriculture, all show traces to antiquity.