

## Lecture 32

# Agricultural Scientific Revolution: Mechanical

### Power and Mechanization

An enormous number of mechanical advances are inherent in the development of agriculture. These include plowing and cultivation using animal traction and irrigation technology involving the lifting, moving, and storing of water. These “machines” underwent continual improvements but remained essentially the same for thousands of years. In the early 19th century, mechanical advances such as the McCormick’s reaper and the cotton gin, invented by Eli Whitney, were to profoundly affect agriculture and enabled the industrialization of agriculture. In the 19th century (the age of steam), steam-powered tractors and threshers were attempted but the engines were costly to operate, required tenders for water and coal, and were dangerous, as well as fire hazards to fields and farmsteads. The gasoline engine was to transform agriculture in the 20th century. In 1892, John Froelich built the first successfully operating gasoline tractor, concurrent with the gasoline-powered automobile. The iron beast took over and there were soon scores of companies developing farm tractors. In 1923, the Farmall, a tricycle type row-crop machine, produced by International Harvester, marked the agricultural transition from horse to machine. In the 1930s, the invention of the power take-off permitted the tractor to be the basic farm machine able to power a score of other operations. On US farms, horses for traction peaked in 1919 (26 million) and dropped to 4 million in 1955, many of which were for recreational use. From 1940 to 1950, tractors increased from 1.6 to 3.4 million.

While the early tractors were used to pull machines formerly drawn by horses, over time various pulling and harvest machines have merged into 1 self-propelled unit: the combine. Breeders have adapted the plant to the machine by selecting for uniform ripening, erect stems to permit drying on the plants, and uniform height and grain presentation. Mechanical harvesting, which started with grain crops such as wheat and maize, expanded to a number of other hard-to-harvest crops such as cotton, tomato, raspberry, and cherry. Similarly, great advances were made in mechanical planters and transplanters; the rice transplanter adapted to small plots in inundated “paddy” fields is one of the most beautiful examples of agricultural machines.

The mechanical revolution was to profoundly change agriculture. Small self-sufficient farms could no longer compete and agriculture got bigger and capital intensive. The trend continues.

### Environment Control

Attempts to control the environment of plants has precedents that date to antiquity. Pliny discusses a greenhouse (*specularia*) using “transparent stone” (mica) to force cucumbers, beloved by the emperor Tiberius. In the 18th century, glass coldframes were developed to force seedlings, using heat generated from rotting manure. The glass greenhouse, based on an iron superstructure and heated by steam, developed in the 19th century. Elaborate conservatories were built on the estates of the wealthy and in botanical gardens. Soon an industry developed for the production of ornamentals and cut flowers. In the 1950s, the development of polyethylene plastic made controlled environment agriculture possible with inexpensive structures that had a profound effect worldwide on production of out-of-season vegetables in desert and subtropical climates, and for early season production. These advances effect on horticulture internationally.

### Irrigation

Irrigation technology has been intimately associated with early agriculture and the basic advances of dams, syphons, simple water lifting devices were an integral part of agriculture in antiquity. By the 16th century the development of hand operated pumps are illustrated but these devices were not to have an important place.

In the 20th centuries, great advances in water diversion technology expanded in dry areas such as the West in the US, particularly California. The development of irrigation technology in the last half of the 20th century was due to the development of lightweight aluminum pipes, the development of sprinkler technology,

and the development of trickle irrigation in the 1970s. Trickle irrigation, is a water delivery system in which water is delivered to individual plants through narrow plastic tubes containing an emitter that adjusts for differences in pressure. Trickle irrigation was first used in greenhouses (where it was known as the Chapin system) and was adapted for field use in Israel. It was developed for arid areas to conserve moisture and to avoid problems of salt buildup. It proved to be adapted to temperate climates and has had enormous benefits to both fruit and vegetable production.

### **Information Technology**

The development of information technology traces to the beginning of writing 5000 years ago from cuneiform to hieroglyphics to the development of the alphabet. Advances in antiquity included the development of papyrus, sheepskin, and paper to receive written information, and the concept of the scroll and book, as a form of information storage. The invention of the printing press by Gutenberg (1453) generated a means for the inexpensive production and storage of information via the printed book. In the 19th century the long distance transmission of information was made possible with the development of the telegraph (Samuel Morse, 1844), the telephone (Alexander Graham Bell (1876), and the radio (Guglielmo Marconi 1901). The explosion of information technology in the 20th century involves the computer, (although devices to calculate such as the abacus, and machines such as Babbage's Difference Engine, are much earlier), and finally the internet and world wide web, satellite imagery, email, and global positioning system (GPS) based on satellites. All influence agriculture. A new development called precision agriculture uses sensors and information technology permitting machines to adjust for individual crop demands. Finally, the development of statistical theory, has had a large influence on agricultural research including plant breeding.