word in title or in text indexes. The language barrier is yielding to translations of parts or complete journals and to listings and indexing of translations available for distribution.

The outstanding, most used, and broadest of all literature services for the food industry is Chemical Abstracts Service. They process about 12,000 serial publications. Information is condensed and integrated into a large inventory of chemical knowledge. This unit is used in toto; and the system has the capability of mechanically separating units on polymers, biochemistry, foods, or a single chemical, food, or beverage. Although this contains the biggest inventory of knowledge on food, there are separate plans in the development stage to serve the food industry's needs in all their ramifications. This could include information of farm and food industry mechanical developments, marketing, packaging, food laws, etc. There are also activities toward integrating all information.

To conclude briefly, may it be said that the types of literature required by the food industry scientist and technologist are dispersed among the writings of many different peoples and disciplines. It is hoped the small number of samples mentioned here indicates this situation.

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History, Evolution, and Status of Agriculture and Food Science and Technology*

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Agriculture and food science and technology are characterized by a series of revolutions. The elements of these revolutions are delineated from early man's success in being the hunter and not the hunted to the current efforts of research and development towards the fabrication of food for the space age. One of the current efforts is the management of information in all areas of and related to agriculture and food science and technology.

Evidence for the importance of agricultural and food science and technology is seen almost daily in newspapers, magazines, books, and scientific journals. Hunger and famine are, of course, news. The somber facts are that the population of the hungry world is increasing at the unprecedented rate of over 3% per year while food production is increasing at less than 1% per year. Famine is now predicted for 1975. Although the great famine is yet to come, the Food and Agriculture Organization of the United Nations estimates that every day 10,000 people die of starvation and two billion people are hungry or malnourished. The world population now totals 3.4 billion, and by the year 2000 the population is expected to exceed 6.5 billion. (*6, 10, 17*)

Two possible solutions are apparent: population control and increased food production. Both directions surely will be taken. It is our hope that this symposium will contribute materially to the second—increased food production.

If science and technology are to be mobilized for the war against hunger and famine, we should at least be aware of what we do not know, what we have done, and what we are doing. In short, is there a literature of agriculture and food science and technology? Is it well defined in terms of awareness and retrieval? Or is knowing what is known one of our problems? The participants in this symposium think that this is the situation, and, taken together, they present a convincing case for the need to harness the literature. Let us first, however, take a perspective look at the history, evolution, and current status of agricultural and food science and technology.

Prehistorical man was of necessity a food gatherer and hunter. He differed from others in the animal kingdom by his ability to improvise and to devise tools for his foraging, hunting, and fishing. The degree of his success in devising the spear, bow and arrow, blow-gun, fish hook, and trap was a measure of his control of his environment. At least he could be the hunter rather than the hunted.

One of the great discoveries of man was fire, probably discovered by Paleolithic man during the period 1 million to 8000 B.C. Fire supplied him with heat, provided him protection against animals, and, once he learned to apply it to the preparation of food, augmented his diet of fruits and roots with cooked meat. Fire allowed him to preserve food, and thus extended further control of his environment. Just as fire led to cooking and preservation of foods, so cooking led to the invention of cooking utensils, braziers for heating, and, eventually, to pottery and metallurgy.

The importance of salt as a food preservative, particularly for meat, was another great discovery of prehistoric man, so great that salt became a prime item of trade and remained so well into modern times.

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Man's domestication of animals undoubtedly was a gradual, empirical process. The dog and also probably the goat and sheep were among man's successes in the Old Stone Age, 17,000 to 8000 B.C. It is probable that the pig, steer, and horse yielded to man by the Late Stone Age or Neolithic Age. Many centuries passed, however, before man realized that animals could be bred for meat, hides, or milk.

Man's greatest change came with the innovation of agriculture. We do not know when or how agriculture began. Agriculture did exist some 8000 years ago, marking the emergence of community life and civilization. The innovation of agriculture forced man to learn to cooperate with nature in what to plant, when to plant, and when to harvest. It forced man to cooperate with his neighbor and to protect his community from conflicts with animals and other human beings. It forced him to learn about his environment, to begin to solve the riddles of nature, to begin to think in terms of energy.

Although we do not know when or how agriculture began, it is fairly certain that cereals arose from the natural cross-breeding, and finally cultivation, of wild grasses in Syria and in the Euphrates and Tigris deltas. As civilization spread through the Mediterranean region, two new cereals, oats and rye, were discovered in Europe and these became the mainstay crops in the Roman Empire. One of the great achievements of the Sumerian civilization was an irrigation system, probably built in 4000 B.C., for the crops of barley, dates, and many vegetables. The very early civilizations intentionally cultivated plants such as flax and hemp for use as fibers for textile and rope. The Egyptian civilization used the papyrus plant for ropes, mats, sandals, and paper; they cultivated certain plants for their extracts of oils and for dyestuffs; specimens of linen were woven 4000 years ago in Egypt on hand looms; fermentation to alcoholic beverages, such as beer from barley and wines from fruits, was known in the Egyptian and Mesopotamian civilizations. The plow, drawn by oxen, was well known in the Babylonian civilization. A remarkable achievement of a very early Chinese civilization, probably before 2000 B.C., was the silk industry. This involved breeding of worms and feeding them on mulberry leaves for the secretion of silk which the worms emitted during the weaving of cocoons. Cotton was spun and woven in ancient India before 2500 B.C. (*9, 15, 16*).

Agriculture throughout man's history has been the primary form of technology. Indeed, until relatively recently, over 90% of the population worked the soil and processed the foods that supported the whole population. Despite the great importance of agriculture and food to mankind and the great discoveries and inventions of man as he emerged into early civilizations, progress was painfully slow. A new system of cultivation did appear in the sixth century with the introduction of a plow with wheels, a vertical blade (coulter), a horizontal plowshare, and a mouldboard to turn over the sod. Because this new plow required eight oxen, its adoption led to communal farming. The modern horse harness appeared in the ninth century and by 1100 A.D. horses were widely used for plowing. This was a major advance as horses can work about twice as fast as oxen; it also made oats for feeding horses an important crop throughout Europe. The invention of nailed horseshoes just before the tenth century made transportation of foods possible throughout most of Northern Europe. Such were the elements of the agriculture revolution in the early Middle Ages.

The European economy, from the early days of the Roman Empire until relatively modern times, was dominated by agriculture. Populations expanded in good agricultural years, and declined in bad years because of malnutrition and starvation. Advances in agricultural technology from the Black Death of mid-fourteenth century until late in the 17th century accounted for the major upswing in population. As the population increased, particularly during the 16th century, the greater demand for food was met by the re-introduction of fertilizers, such as manure, seaweeds, and marl or limestone. The potato was introduced into Spain from South America, thus increasing the food supply appreciably as potatoes yield more calories per acre than any other easily grown crop. Sugar cane was brought to Europe from the New World in the 17th century, becoming the sweetener for the poor by replacing honey; its by-product, molasses, yielded rum by fermentation. Tobacco, corn, and cotton were also brought in from the Americas, and cocoa, tea, and coffee became important products of world-wide trade. (*9, 15*)

The elements of the agricultural revolution of the 18 to 19th centuries were: new fodder crops, four-crop rotation, and fenced fields; new machines, such as seed drills, threshing and winnowing machines, chaff cutters, and improved plows; the breeding of farm animals; and the introduction of veterinary medicine.

Towards the end of the 19th century and well into the 20th century, the power revolution in agriculture changed farming from a one-man or one-family operation into a whole new industry. McCormick's reaper (1834) and Deere's steel plow (1837) presaged the change. The replacement of the horse with gasoline-powered tractors and trucks in the 20th century marked the beginning of the end of this change in farming. Farm mechanization alone, however, could not have wrought the revolution successfully. Other concomitant factors were needed.

Farm mechanization and the introduction of chemical fertilizers to replace Chilean nitrate materially increased the agricultural output. The preservation of food was so critical, particularly for armies, that the French Government (Napoleon I) offered a prize (12,000 francs) for devising a method. This prize was won by Nicholas Appert in 1810 for his method of preserving foods by placing the food to be preserved in a stoppered glass bottle and immersing the bottle in boiling water, and thus began the canning industry. Why Appert's method worked was not understood, however, until the 1860's when Pasteur announced the results of his work on the effect of heat on microorganisms. A notable result of Pasteur's work was the extension of milk as a food by pasteurization. The use of canned goods was further advanced in the United States by the needs of the Union army during the Civil War for tinned milk and meat. Although large scale refrigeration began in the early 1800's by the use of ice, the deterioration of meat above 40° F. resulted in most slaughtering being relegated to the winter months. Refrigerated freight trains were introduced in the 1870's and refrigerated slaughter houses in the 1890's, the latter being made possible by the widespread growth of electric power and, consequently, mechanical refrigeration. A rapid evolution took place with advances in mechanical refrigeration, resulting in new cold-storage techniques, the introduction of mass produced foods such as ice cream, and since 1925, in the development of the food-freezing industry. (*5, 8, 9, 14, 15, 16*)

In the United States, universities were the first centers of agricultural research. They became even more important with the Education Land Grant Act in the 1860's. Characteristic of university research in agriculture has been its coupling with operational use of the results. Another important impetus to the development of agricultural and food science and technology has been the many experiment stations and extension services of the States and the regional laboratories of the USDA. These factors demonstrated time and again the economic value of research to the farmers, the food industry, the machine industry, and the chemical industry. Beginning after World War I, and especially since World War II, a great deal of research and development has been conducted in industrial laboratories. This has resulted in new foods, new food additives, more efficient fertilizers, new chemicals for the control of plant diseases, insect pests, and weeds, and new machines. Another recent development has been the formation of scientific and technical societies, such as the Institute of Food Technologists and the American Chemical Society Division of Agricultural and Food Chemistry. These societies have introduced new journals, such as *Journal of Agricultural and Food Chemistry* (American Chemical Society) and *Journal of Food Science* and *Food Technology* (Institute of Food Technologists). They also hold meetings for the dissemination of new results from research and development programs and provide a continuing communication link among scientists actively working in the many areas that comprise agricultural and food science and technology. Another recent example is the International Rice Institute which was formed in 1961 under the joint sponsorship of the Ford and Rockefeller Foundations to study genetics and breeding, physiology, pathology, engineering, entomology, crop production, management, and rotation, economics, and expansion of rice as a crop. This is singled out to illustrate the various disciplines of science which are enlisted in just a single crop (*18*).

In brief, the elements of the current agricultural revolution are (*4, 5, 8, 14, 18, 19*):

Plant genetics and breeding for increased plant yields per acre and for the growing of disease-free and pest-resistant plants.

Animal genetics and breeding for more efficient conversion of animal food to human food.

Nutritional aspects of animal and human needs.

Analytical methods and instrumentation for detailed analysis of foods and understanding of functional aspects of food.

New technological advances, including automation and instrumentation, in farming, food production, processing, preserving, packaging, storing, transporting, and merchandising.

New food additives for the production, processing, preserving, and marketing of foods.

New food sources and new foods through modification, fabrication, and fortification.

Introduction of convenience foods and more and better specialty foods.

Complete utilization of foods, including by-products, as, for example, the pig except for his squeal, and, more recently, conversion of fish to a concentrated food.

More efficient and complete fertilizers.

New chemicals for the control of plant and animal diseases, insect pests, and weeds.

New institutes, societies, and laboratories for research and development and for the communication of the results.

Academic recognition of the changing objectives and scope in the education of food scientists.

Psychological studies of the consumer's customs, habits, etc., in his acceptance of new and different foods.

The current agricultural revolution has resulted in a food industry in the United States that had a total sales of $77.7 billion in 1966, making it the sales leader of all industries. Transportation was second with sales of $74.6 billion, and chemicals was sixth with sales of $44.5 billion. There were 124 companies in the food industry with sales of over $40 million; there were 90 chemical companies in this category (*3*). The current agriculture revolution resulted in the U. S. production of more than 7 billion pounds of broilers in 1965, a 70-fold increase over the 1934 production of about 100 million pounds. It resulted in the U. S. production of over 4 billion bushels of corn in 1963 from 60 million acres in contrast to 2.5 billion bushels per year in the early 1930's from about 100 million acres. (*7, 12*)

Despite the obvious benefits of the development of hybrid corn by geneticists and plant breeders, it took over 40 years for hybrid corn to become a commercial product (*13*). Despite the obvious advantages of fertilizers, discovered by early man and re-introduced by European farmers in the 16th century, fertilizers were not widely used in the United States until a relatively few years ago when governmental control of agriculture output, based on acres planted, was countered with the widespread use of fertilizers.

In the grand perspective of the history and evolution of agriculture and food science and technology, most of the interplays of knowledge and its applications have been largely affairs of chance. Until well into the current revolution, agriculture and food was mostly a matter of art, handed down from generation to generation and transferred from one civilization to another. There were technological advances, but these were slow in coming and in developing. Yet each of the agricultural revolutions over the ages was well delineated and evolved progressively into its successor.

The current revolution is unique. Although it is still in progress, a new agricultural revolution is being superimposed on it. Many of the elements of the new are those of the current, the difference being mostly one of emphasis, direction, and planning, with money and effort in support (*1, 2, 4, 11, 18, 19*). The new revolution has arisen in response to the need for food of the expanding and projected population of the world. The new revolution is characterized particularly by science and technology. It is beginning to show progress in desalinization of ocean and brackish water for irrigation of land that has not been arable; the production of foods from oceans and inland waters; the exploitation of seaweed and plankton as significant sources of food; the fabrication of synthetic proteins from microorganisms, algae, and petrochemicals; the application of ecology, such as in the effect of air and water pollution; the application of animal and plant genetics; the production of synthetic vitamins, amino acids, carbohydrates, and the conversion of wastes into foods; the fabrication of foods acceptable to various peoples throughout the world in terms of flavor, appearance, and texture as well as religion, culture, and custom; the fabrication of nutritional foods to prevent malnutrition in areas of plenty as well as in areas of starvation and famine; the fabrication of food for the exploration of space; and the management of information in all areas of and related to agriculture and food science and technology.

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CAS as a Literature Source for Agricultural and Food Science and Technology*

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The purpose of this paper is to help users find agricultural and food chemistry information in Chemical Abstracts Service (CAS) publications and services. It is primarily a narrative catalog of the characteristics of our output, intended to help the agricultural and food chemist decide which of his information needs may be satisfied in whole or in part by a CAS publication or service.

The information needs of each and every field of science cannot be met at present. Chemical Abstracts Service (CAS) does, however, by treating comprehensively all of chemistry and chemical engineering, provide a significant amount of information to special fields, among these, agriculture and food science. The primary mission of CAS, of course, is to make chemical and chemical engineering information and its bibliographic identity more readily available, more useable, and more used.

CAS-produced sources of information about agricultural and food science include *Chemical Titles, Chemical Biological Activities, Polymer Science and Technology, Chemical Abstracts* Issues, Issue Indexes, Semi-Annual Volume Indexes, Five-Year Collective Indexes, and the new *Basic Journal Abstracts* and *CA Condensates*. Soon, the Chemical Compound Registry System and the Substructure Search System for computer search of files of structural formulas will be added to CAS services now available to subscribers.

On January 1, 1968, *Chemical Abstracts (CA)* began its 62nd year of publication. The structure and format of *CA* have changed from the few broad, textbook-like category headings first used in 1907 to the present complex, detailed, and discipline-oriented 80 sections of chemistry and chemical engineering. This change is a fascinating and revealing reflection of the evolutionary growth and development of the sciences and technologies reported in *CA*. From the beginning, *CA* and now its parent CAS have pursued a number of objectives, including complete coverage of chemistry and chemical engineering, informative abstracting, and indexing to maximum

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