INTRODUCTION

Agricultural and Food Chemistry: Accomplishments and Perspectives

The cover of this issue celebrates the 75th Anniversary of the founding of the Agricultural and Food Chemistry Division of the American Chemical Society (ACS). There is a nostalgic feeling about Diamond Jubilees that implies something must be right to justify 75 years of existence. Our group was first organized in 1904 as the Section of Agricultural, Sanitary, and Physiological Chemists; later in 1905 it became the Section of Agricultural and Sanitary Chemists and further changed to the Section of Agricultural and Food Chemists. By 1907, the Society membership had a strong desire to be identified by specialty. The ACS decided to form its first five divisions in 1908. The Agricultural and Food Chemistry Division was a leading group identified within this new structure.

The spirit of Agriculture and Food Chemistry pervaded throughout the ACS long before the formal organization of the Agricultural and Food Chemistry Division. History points out that U.S. agricultural and food scientists played a leading role in the founding of the ACS. In those days American chemists beat a path to Justus von Liebig's laboratory at the University of Giessen and to other universities on the European continent so that it became the style of leading agricultural experiment stations to staff their laboratories with American chemists trained overseas. Professor Liebig, the "father" of agricultural chemistry, laid the foundation for the fertilizer industry and soil enrichment as we know it today. It should be remembered that the development of the steel-faced plow during Liebig's time led to mass production of grains since it allowed the soil to be turned over at a depth adequate for killing the grass. Liebig's influence was recognized by the ACS when it incorporated the Liebig flask in its emblem.

Our first Division Chairman was W. D. Bigelow; W. B. D. Penniman was secretary. The first formal Division program was held in 1909 and the first paper, christening the beginning of a very exciting era in food chemistry, appropriately dealt with whiskey. It was significant that Prof. E. V. McCollum of the University of Wisconsin and a member of our Division came to grips with the unidentified growth factors that had perplexed food and nutrition chemists during that period. It has been written that McCollum "changed our understanding of nutrition in much the same way as Albert Einstein (also born in 1879) revolutionized the study of the universe" (Day, 1979). Whereas Liebig classified food constituents as proteins, carbohydrates, fats, and minerals, McCollum helped provide a reliable basis for evaluating the nutritive value of foods by establishing the first rat colony for experimental nutritional studies. This approach became a major tool in the discovery and understanding of nutritional knowledge so important for application in agricultural production as well as in prevention of disease in humans.

The Division targeted its goal to sponsor symposia in specialized areas and in 1922 held its first symposium in Pittsburgh on edible oils and fats. The Division was quite active in the field until the mid-1920s when, due to lack of interest and enthusiasm, it was apparent that it had already achieved its purpose and was about to be abandoned. At the 1924 meeting, the session dwindled to only six miscellaneous papers. By 1925, interest in the Division was further reduced when the few members present joined with the Division of Biological Chemistry and did not hold a separate meeting. At the 1927 meeting in Detroit only four papers were scheduled for presentation. At that time it was decided to give up the Division and consolidate with the Division of Biological Chemistry. A committee set up to confer with both divisions on the feasibility of this merger reported that such a consolidation was inadvisable. The main objection against the merger was that the research field covered by the Division was too broad to attract and sustain the continued interest of members oriented only in biological chemistry.

Following this development, several farsighted dynamic individuals put forth effort to reorganize the Division. Using *Industrial and Engineering Chemistry, News Edition*, they solicited active sustaining members, collected dues, and organized symposia. An excellent symposium of 42 papers on insecticides, organized by R. C. Roark for the 1928 meeting, was so successful that it gave sustained vitality to our Division, making it one of the most active Divisions of the ACS. The first vitamin symposium was held in 1935. At that time, the vitamin mysteries were being unraveled by the use of the rat and other small laboratory animals in nutrition research. Our Division leaders recognized the universal interest in this subject and repeated this vitamin symposium at least 20 times before 1960. Since the Divisions's interests encompass the biological, medicinal, fertilizer, cellulose, sugar, colloid, and industrial chemistry fields, many of the programmed symposia have been cosponsored by other divisions of the Society. In addition, our Division sponsored successfully two international conferences, in Athens, Greece, in 1978 and 1981, and have scheduled two more, in Corfu, Greece, one in 1983 and the other for 1985.

In order to cover the broad scope of the Division to include nutrition, fertilizers, insecticides, fungicides, rodenticides, herbicides, fermentation, crops, flavor, and food technology, our Division created a number of subdivisions. These subdivisions played an important part in our diversified activities. Our spirited paternal enthusiasm provided to offspring subdivisions the freedom to grow and prosper so that upon maturity they could become independent divisions. In 1936 scientists working in the area of microbiology attempted and failed to form a fermentation subdivision within our Agricultural and Food Division. Industry opposed such a movement because it was reluctant to reveal trade secrets. World War II needs increased the demand for fermentation chemicals and pharmaceuticals, thereby forcing industrial, academic, and government chemists to get together and form a Fermentation Subdivision in 1946 chaired by C. S. Boruff. Since its inception, it has been extremely active. In 1961, it was given an independent status and became the Division of Microbial Chemistry and Technology. Our Pesticide Subdivision was formed in 1950 with J. L. St. John as its first chairman. It was very successful within our Division until 1968, at which time it became a separate Division of Pesticide Chemistry. Thus, we can take a great deal of pride in the fact that our Division of Agricultural and Food Chemistry fostered the formation and development of two

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new great Divisions in our American Chemical Society. Even though there was some loss of Division membership with the separation of each Subdivision, the loss was soon made up by the continued healthy growth of the parent Division. Presently, our membership is nearly 1600 and growing. Currently, the Division has four subdivisions. The Flavor Subdivision was founded in 1965 with I. Hornstein as chairman; the Food Biochemistry Subdivision (which is the former Protein Chemistry Subdivision created in 1970 with G. E. Inglett as chairman) was founded in 1980 with J. P. Cherry as chairman; the Nutritional Chemistry Subdivision was established in 1977 with L. Rosner as chairman; the Agrochemicals Subdivision was founded in 1982 and chaired by Robert Ory.

In the 75 years of the exciting history of our Division, we have been responsible for the organization and presentation of over 5200 papers and over 130 symposia and international conferences. It has been fortuitous that the subjects chosen by our Division leadership over its 75 years of existence have been far ahead of the times and helped forge a pathway to the road ahead in the discoveries that followed.

The wide ACS membership interest in symposia provided an incentive in 1949 for the ACS Board of Directors to give the editors of *Industrial and Engineering Chemistry*, *Analytical Chemistry*, and *Chemical and Engineering News* permission to publish symposia in their entirety in book form. The vehicle for this publication was named "Advances in Chemistry Series". Our 1949 Symposium on Economic Poisons organized by our Pesticide Subdivision was given the honor of appearing as No. 1 of the "Advances in Chemistry Series" under the title "Agricultural Control Chemicals".

With the many activities of the Division receiving public attention and interfacing with the news media, it was felt necessary to pioneer setting up a public relations group to improve the image of the Division. The enthusiastic Harry J. Prebluda served as the first chairman of public relations from 1973 to 1980. It was at that time that our Division was represented on *CHEMTECH*'s Advisory Panel. The first edition of the Directory of Members and Divisional History, which was published in 1982, was an outgrowth of this dynamic public relations group.

We have come a long way in the last 75 years where we witnessed the changeover in agriculture from the muscle of men, horses, and mules to a system based largely on mechanized operations. The internal combustion engine and space-age technology with its orbiting satellites have produced improvements in agricultural production and communication skills beyond the dreams of our forefathers.

AGRICULTURAL ACCOMPLISHMENTS

It is fitting during our Diamond Jubilee Anniversary to look back briefly at the most significant achievements in the development of agriculture, food chemistry, and nutrition.

As previously mentioned, Professor Liebig of the University of Giessen is the "father" of agricultural chemistry. He trained many American students in his laboratory in the 19th century. One of these students was chemist C. M. Wetherwill, who in 1862 became the first scientist in the U.S. Department of Agriculture (USDA), a distinction received from President Abraham Lincoln.

The era of U.S. agricultural science began shortly before the establishment of the ACS with the Morrill Act of 1862 encouraging the creation of colleges for teaching of Agricultural and Mechanical Arts. This was followed by the Hatch Act of 1887, which provided funds for the establishment of a system of state agricultural experiment stations modeled after the first experiment station in Connecticut. The driving force behind the inception of the first station was pioneering agricultural chemist Samuel W. Johnson, another student of Professor Liebig. He was one of a few farsighted individuals who envisioned the valuable role of science, in particular chemistry, in agriculture. This pioneer felt that this objective could best be achieved through the establishment of agricultural research stations modeled after those already in existence in Germany. After much campaigning by Johnson, the Connecticut legislature in 1875 passed a bill creating the first Agricultural Experiment Station at a laboratory donated by Wesleyan University. A former student of Johnson's, W. O. Atwater, was the first director of the Connecticut Station. Later, Atwater distinguished himself as an outstanding researcher in respiratory calorimetry. Shortly thereafter, another bill authorized moving the experiment station to New Haven, and S. W. Johnson was appointed Director. Johnson's prominence as an agricultural chemist and a dynamic leader was recognized in 1878 when he was elected president of the American Chemical Society and again in 1884 when he became the first president of the Association of Official Agricultural Chemists.

At the beginning, agricultural science concerned itself with soil chemistry and soil improvement using fertilizers. Later, state chemists who were in charge of analyzing the quality of fertilizers became interested in the quality of farm products. The Kjeldahl method for nitrogen analysis became available in 1883, and the Babcock milk fat test was developed in 1890. A law regulating the quality of milk was enacted in Connecticut in 1882. The Federal Pure Food and Drug Law was passed in 1906 largely through the efforts of Dr. Harvey Wiley, the famous USDA chemist who was president of the ACS in 1893.

The development and application of "the newer knowledge of nutrition" have been two of the most significant achievements in human history. Liebig had classified food constituents broadly as proteins, carbohydrates, fats, and minerals, but studies performed at the beginning of 1900 helped in the understanding of specific chemical requirements of nutrition. Prof. Elmer V. McCollum of the University of Wisconsin pioneered in discovering the unidentified factors that had mystified nutritional chemists for years. From 1907 to 1917, McCollum brought into focus many different facts and views to help formulate the basic concepts of nutrition. He saw the body as a chemical factory. For this reason, his main objective was to determine the minimum amounts of chemical substances the body needed to function normally. Although he started his studies with young cows, he decided later that it would be much more efficient if he used smaller animals with a shorter life span. On this basis, he selected the rat which at the time was an unheard-of and repugnant notion. He met with resistance, and the Dean of the College of Agriculture refused to support such a project. But McCollum's mentor, Prof. S. M. Babcock, prevailed, and McCollum was allowed to carry out his research. McCollum's approach led to the establishment with his own funds of the first rat colony for experimental nutrition studies. Among his landmark discoveries, he found that certain fats, including milk fat, contain an indispensable nutrient later called vitamin A. His introduction of the biological method for the analysis of foods yielded remarkable results. McCollum and his associates discovered vitamin D, a deficiency of which was the cause of rickets. Under his direction, other dietary essentials were discovered, and knowledge of specific effects of nutrient insufficiency and imbalance was advanced. As chemists elucidated the vitamin mysteries, it became clear that the newly discovered vitamins were all needed for growth and good health.

In addition to the vitamin research progress during this period, the nutritional requirement for various trace elements was recognized around 1928 and that of essential fatty acids in 1932. Osborne and Mendel had reported in 1913 on the dietary requirements of specific amino acids, and in the next 25 years, the approximate requirements of man for all the essential amino acids had been determined. The nutritional knowledge acquired during this period was not only of direct value to human health but also of application to the health and productivity of livestock.

With the advent of research methods such as radiochemistry, biochemists have brought about greater understanding of plant physiology. Calvin, Arnon, and their coworkers elucidated the pathways of carbon in photosynthesis and energy. Furthermore, significant advances were made in understanding the chemistry of nitrogen fixation; applications to agriculture soon followed the discoveries of auxin, the gibberellins, kinetin, and ethylene. The development of a lysine-rich corn was the result of work by E. Mertz and his co-workers at Purdue University. Pesticides, soil studies, and fertilizers have played essential roles in accelerating agricultural progress. Flavor chemistry, protein chemistry, food chemistry, and enzymology continue to elucidate the profile of food constituents.

About a century ago, 50% of the U.S. labor force produced the food and fiber necessary to feed and clothe the nation; in 1910, about 35% of the labor force was engaged in farming. Today, we feed our country and export 20% of farm production with only 3% of the labor force working directly on the farms. We do not often realize the many contributions made by scientific agricultural research to improve our every day activities centering around food, clothing, and shelter. Although the farmer has benefited tremendously from this agricultural research work, its impact has been much broader than just the farm. About 100 years ago, the U.S. annual corn crop was only a billion bushels per year. Today it is at least 6 times as great and is of improved nutritional quality.

Our Division became the launching pad for the exchange of information on feed efficiency developments. An era of relatively low cost food production was ushered in as a result of the improved feed efficiency. Today's chicken, for example, is a far cry from its counterpart a hundred years ago. Just in the past 30 years, agricultural research has shown how to produce a pound of chicken with less than half the necessary feed required earlier and to grow the chicken to maturity in less than half the time. A vaccine developed at the Virginia Agricultural Experiment Station to protect poultry against Newcastle disease is estimated to have a worldwide value of over a billion dollars.

Our Division has been instrumental in showing the farmer how to do more with less. To mention a few examples, the scientific breakthroughs just in the last 25 years enabled us to almost double milk production with half as many animals. Meat and egg production in the United States have doubled in the past 45 years. Although the total land planted in cereal and soybeans in 1929 and 1974 was the same, 89 million hectares, the total production of cereal and soybeans in 1929 was 115 million metric tons as compared to 245 million metric tons in 1974.

WHAT ABOUT THE FUTURE?

Predicting the future and forecasting have their hazardous points. The world in the year 2000 is expected to be not only more populated, polluted, and ecologically unstable but also more disruptive than the one we live in today. The social and political stresses involving population, resources, and environment are clearly visible ahead. It is imperative that we ease these stresses by improved efficiency in our agriculture and food production to counteract the population explosion and expected land and water shortages. At stake is our export and world trade balance should our agricultural economy fail to meet the challenge. To meet future challenges, innovation is needed to capitalize on the yet unexplored opportunities. Only by searching out these unrecognized values with new breakthroughs in plant and animal growth regulators, biotechnology, genetic engineering, and other novel techniques will we be able to develop disease-resistant, highly productive plants and animals. Such approaches will assure increased production of grains, fruits, vegetables, meat, poultry, milk, and other foodstuffs. Ongoing research indicates that it is possible through genetic manipulation to enhance the efficiency of photosynthesis, which can radically increase farm output in gigantic proportions.

Furthermore, if we are to bridge the gap of knowledge, greater understanding and cooperation will be necessary between marine and agricultural research scientists. Although agriculture has made enormous progress in increasing its productive efficiency in the last 100 years, exploitation of the waterways and oceans has only just begun. In a recent analysis (Pontecorvo et al., 1980) of the ocean economic sector, it was estimated that the annual ocean sector value is $30.6 billion in 1972 dollars, which is only slightly below that of agriculture ($35.4 billion). In addition to increasing production of food from marine salt-tolerant plants (halophytes) and animals, a number of marine products and byproducts have already shown promising applications. For example, compounds derived from such material appear to have advantages for developing herbicides, insecticides, and fungicides because they are more effective than those they replace and are biodegradable and usually harmless to the environment. An increasing number of marine-derived materials are already being used. For example, chitin [poly[β(1→4)-*N*-acetyl-D-glucosamine]], obtainable in tonnage quantities from crab, shrimp, and lobster shell waste of the seafood industry, is used in medicine, disease control of plants and animals, food, and nutrition. More specifically, chitin has been used as a blood anticoagulant, a wound-healing accelerator, a surgical suture, and a supplement in the digestion of surplus cheese whey. Chitosan (deacetylated chitin) has been proposed for making an artificial kidney membrane. Despite these medical and nutritional applications, chitin and chitosan are still little utilized. It is known that low molecular compounds pass through membranes made from chitin and chitosan. Since chitin and chitosan do not present any biological hazard and they are inexpensive, these natural polymers may be suitable for use as carriers for the sustained release of commercial drugs. Presently, chitosan is also being used as a flocculent in municipal and industrial waste water treatment to clean water from heavy metal contaminants.

The 1983 year of celebration is a major challenge to our nation's agriculture since the entire world has been involved in the crisis struggle of battling economic recession. The question of continuing agricultural research in the face of a long period of double-digit inflation has left an indelible mark on our conscience in spite of record grain yields. Surplus commodity and resulting low farm prices have created near disaster conditions for many U.S. farmers. We are constantly engaged in such challenges to make use of our knowledge so that we can correct inequities. Lest we forget, research is the order of the day to make changes for improving conditions. What follows are some additional important developments in agricultural and food chemistry that can be expected in the future.

Recombinant DNA will be a powerful experimental tool to improve present technologies for converting biomass to chemicals, including oil production from algae. Such developments could ease the pressure of petroleum and other fossil fuels used as feedstocks. Melvin Calvin recently estimated that it is possible to meet all U.S. energy needs from green plants genetically engineered to produce oils that, when refined by conventional methods, could yield diesel fuel, gasoline, and other petrochemicals. We may yet see the day when new approaches to making fuel improvements will make the use of present-day gasohol seem antiquated. Catalysis may unlock the available forces that hold together the fuel molecules and indirectly improve the efficiency of fuel conversion. Cellulose, hemicellulose, lignin, starch, whey, chitin, and other biorenewable resources hold great promise in bioconversion strategies.

Look for unusual changes in methods of energy calculations relative to nutrition. The food and animal feed industries will be looking into this area in terms of "spectral energy density". This is a recently developed measure reflecting concentration of chemical energy in the various atoms in relations to the mass of a molecule. Spectral energy concepts will play a role in guiding the formulation of bioconversion fermentation products so that they can be used optimally in upgrading the quality of ingested protein. These new concepts will also provide a profile for sophisticated feed formulations computerized for the more accurate prediction of nitrogen retention, protein utilization, and palatability of feeding materials.

Before the end of this century it will be possible for microbes or fungal cells to synthesize a wide range of organic chemicals that are economically unfeasible at the present time. Genetic engineering studies with nitrogen-fixing organisms will enable us to fix nitrogen in the soil for non-legume crops producing starches and sugars. If this is achieved, it will make us less dependent on energy-intensive synthetic fertilizers. Enzymes will play a very important role in the development of new fermentation programs. Immobilized enzymes should find increased applications in continuous reactors where specific conversions will be utilized by the chemical, pharmaceutical, and food industries. Furthermore, enzymes from agricultural materials and byproducts will be extracted and purified in increasing amounts for use in medicine and related industries.

The challenge to apply all new space-age technological discoveries and bring them to fruition at reasonable costs and profits to industry will take a good deal of imagination, patience, skill, and time on the part of chemists, biologists, engineers, and economists.

There is great confidence in our scientific establishment that the "chip" will play a great role in turning a negative to a positive. Forecasters predict that although the computer has already been accepted within the inner circle of American farm operations, its great potential for identifying production inefficiencies not only will conserve our natural resources but also will increase our agricultural production substantially so that it is more profitable. The application of computer technology to food marketing operation is coming of age. Companies are now developing computer software packages with specific refinements in miniturization to make this equipment useful to farmers and marketing executives. Our own USDA played a role in evaluating optical scanning systems in the 1970s to bring about dramatic changes in computer applications for food marketing. Presently, the combination of optical scanners with minicomputers allows supermarket managers to analyze their various operations. Computer to computer linkages are already reducing the great mountains of paper work necessary for processing routine agribusiness. The minicomputer is gaining extensive acceptance in many diversified agricultural uses that range from the control of irrigation to quality, quantity, and timing of feeding farm animals. It is also being used in programs for testing the many new designs for the latest agricultural equipment.

Presently our Division has more than met the performance standards set up by our predecessors. Our Division has been consistently given top rank by the National Subcommittee on Divisions. Recently this Subcommittee acclaimed the Agricultural and Food Chemistry Division as "best by far in enthusiasm, mission orientation, and imagination". However, we should not rest on our laurels and be smug in our own past achievements and accomplishments. We must strive for continued excellence and improved communication with each other and the public at large. Our effervescent enthusiasm in planning our programs should result in greater Division recruitment among the younger members of our American Chemical Society to assure us a smooth road ahead in encountering the expected changes of the next 75 years.

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