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PROFESSOR DEXTER FRENCH

This issue of *Carbohydrate Research* is dedicated to Professor Dexter French in celebration of his 60th birthday.

Dexter French was born in Des Moines, Iowa, on February 23, 1918. He entered the University of Dubuque in 1935 and obtained the degree of B.A. *magna cum laude* in 1938 with a double major in chemistry and mathematics. For his graduate studies, Dexter French entered Iowa State College in 1938; there he studied under Professors R. S. Bear and R. E. Rundle. His Ph.D. thesis, submitted in 1942, dealt with X-ray diffraction studies on starch and its fractions.

From Ames, Iowa, Dexter French moved to Harvard Medical School where he spent two years as a postdoctoral fellow in the Department of Physical Chemistry with Professors E. J. Cohn and J. T. Edsall, studying the reactions of formaldehyde with amino acids and proteins. The year 1945 was spent working in the Argo, Illinois, laboratories of the Corn Products Refining Company as a research chemist. Dr. French returned to Iowa State College (now Iowa State University) in 1946 as an Assistant Professor of Chemistry. He was appointed Associate Professor in 1951, Professor in 1955, Professor of Biochemistry in 1960, and served as the Chairman of the Department of Biochemistry and Biophysics from 1963 to 1971.

Although Dexter French's early training was as a chemist, his leanings were always towards biological chemistry and biochemistry, as is apparent from the directions of his postgraduate training and subsequent research efforts. His early papers with Robert Rundle on the characterization of the starch fractions are classics that have stood the test of time. Using X-ray diffraction, they showed that the amylose molecule is coiled into a regular helix with a hole in the center, and that iodine molecules, together with iodide ions, stack into the hole and cause the blue color that is a characteristic reaction of amylose. This was the first helical structure of a biopolymer to be described, antedating the α-helix of proteins and the double helix of DNA.

Rundle also introduced Dexter French to the Schardinger dextrins (cycloamyloses), oligosaccharides formed by an enzyme from *Bacillus macerans* acting on starch. Cycloamyloses are cyclic oligosaccharides containing six, seven, or more (1 → 4)-linked α-D-glycopyranose residues. For many years, French has been the world authority on the preparation of these compounds in pure form, and on their structure and chemistry. X-Ray diffraction experiments showed them to be shaped like doughnuts and, in 1959, he showed that iodine molecules fit neatly into the central cavities, as do many other small molecules. French's fundamental studies have generated considerable interest in these substances as enzyme models, enzyme inhibitors, and as agents for stabilizing flavoring substances in foodstuffs. At present, there is no major commercial market for cycloamyloses, but one of these days someone will probably find a use for these unusual substances. When that happens, we

shall have Dexter French to thank for his diligent investigations, made many years before.

Both amylopectin, the branched component of starch, and glycogen, the analogous polysaccharide from animal cells, are extremely large, highly branched, tree-like macromolecules. To investigate the detailed structures of these complex molecules, French had to develop and apply some new tools. By the early 1950's, he had mastered the new technique of paper chromatography and developed it to an elegant degree of perfection for use in the analysis of breakdown products of starch and other oligosaccharides. In a classic, short note in *Science* in 1951, he showed how the structure of the then newly-discovered trisaccharide panose could be rapidly and elegantly determined by a combination of partial fragmentation and chromatography. This was the first of many similar contributions employing the paper-chromatographic method, which he applied extensively for the identification of fragments arising from starch by the action of various amylolytic enzymes. French also assembled, from animal, plant, and microbial sources, a battery of these enzymes which were able to break down starch and glycogen molecules in various ways, either stepwise from the outside of the molecule, or by cleaving the chains randomly in the center of the molecule. He took advantage of the synthetic action of phosphorylase to attach sugar groups labeled with radioactive carbon to the ends of the molecules of starch fractions and used the resulting labeled molecules, together with chromatographic techniques, to identify for each enzyme a characteristic action-pattern. Such knowledge permitted him and other workers in the field to apply the enzymes to develop a detailed and precise understanding of the internal structure of the branched starches and of many other complex carbohydrates.

In addition to using enzymes for the analysis of starch structure, he has also made important fundamental contributions to our understanding of the mechanisms of action of starch-metabolizing enzymes. This has introduced us to novel aspects of transglycosylation, condensation reactions brought about by hydrolytic enzymes, the specificity of carbohydrases, theoretical considerations of amylase action, and the specificity of the enzyme that synthesizes Schardinger dextrins. He developed the concept that the distribution of products formed by an enzyme acting on starch is a result of the binding of the individual sugar rings at a number of "subsites" on the enzyme. Elegant quantitative experiments and arguments have supplemented this conclusion. Now that a related enzyme, lysozyme, has been analyzed by X-ray diffraction, the presence of such subsites has been clearly established. French also pioneered the concept that enzymes often act on starch by multiple attack. That is, an enzyme cutting a chain at one point may stay with the same chain and cleave a number of sugar units from it in a rapid, consecutive sequence without dissociation of enzyme and substrate.

The starch granule itself has been and continues to be a source of fascination for French. He continues to study how the molecular chains of starch are laid down by the plant in the crystalline nature in which they exist in the granules, and to investigate what enzymes are involved in the synthesis of the unbranched chains of

amylose and the branched chains of amylopectin side by side. Most notable among his recent contributions has been the idea that the chains in starch granules are present as double helices, a suggestion that is supported by recent X-ray crystallographic studies. This finding has important implications in regard to the structure of the starch granule, the three-dimensional structure of the starch fractions, and the mechanism of starch biosynthesis.

In addition to the fundamental scientific importance of French's work in the field of starch-type polysaccharides, his many basic-research discoveries have led to important practical applications. His careful quantitative investigation of the starch–iodine reaction provided the basis for important advances in the starch industry. It offered a means of accurately establishing the relative content of amylose and amylopectin in starches. This, in turn, paved the way for plant breeders to develop the commercially important, present-day high-amylose corns. An understanding of the structure of amylopectin has allowed the development of better thickening and stabilizing agents for foods. Of particular importance is the ability of thickening agents to retain their effectiveness after repeated freezing and thawing, or prolonged storage at low temperatures. French's fundamental discoveries have effectively helped industrial scientists to tackle these problems. French's understanding of the starch-granule structure and of the enzymology of starch digestion has been instrumental in the development of better quality corn syrups. In the medical field, some of French's contributions to the structure of glycogen have clarified the molecular defects responsible for the hereditary "glycogen-storage diseases" in which muscle or liver becomes engorged with an excess of this material.

Dexter French's outstanding achievements have earned him the respect of carbohydrate chemists and biochemists around the world, as recognized by numerous awards and honors. His *alma mater* recognized his achievement by bestowing the honorary degree of Doctor of Science on him in 1960. Iowa State University appointed him a Distinguished Professor in 1968, and awarded him its Faculty Citation in 1970. He received the Hudson Award of the Division of Carbohydrate Chemistry of the American Chemical Society in 1964, the Award of Merit of the Japanese Society of Starch Science in 1971, and the Alsberg–Schoch Award of the American Association of Cereal Chemists in 1974. His experience, his sound judgment, and common sense have been called on in his activities as a member of the Editorial Boards of the *Journal of Biological Chemistry*, *Carbohydrate Research*, and *Advances in Carbohydrate Chemistry and Biochemistry*. He has also served as Chairman of the Division of Carbohydrate Chemistry of the American Chemical Society, and as a member of the National Institutes of Health Biochemistry Study Section.

Throughout his career, Dexter French has attracted outstanding students. A number of these students have gone on to become leaders in carbohydrate chemistry and enzymology in universities, while others have become influential in the food industry. He has been particularly successful in establishing relations with Japanese carbohydrate scientists, who have the greatest admiration for his achievements, and who have demonstrated this by visiting him for postdoctoral training.

Dexter French has always been a teacher of the highest quality and a person who has inspired excitement and enthusiasm for research among his students, colleagues, and research associates. His hospitality to visitors has been generous to a fault and, through it, many people have come to know his wife, Mary Catherine French, and their large family. It is especially pleasing that his son, Alfred, now at the Southern Regional Research Laboratory in New Orleans, is providing evidence, from X-ray crystallographic studies, for his father's concept of a double-helical structure of starch.

The high esteem in which Dexter French is held is evidenced by the outstanding response to the invitations for contributions to this special issue of *Carbohydrate Research* in his honor, and the many requests from those who, for one reason or another, have been unable to contribute, to be associated in spirit with this tribute to him. As Dexter French reaches his 60th birthday, his huge circle of friends around the world offer him their congratulations for his memorable achievements and wish him many fruitful years of research and teaching endeavors to come.

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