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Carbohydrate Research in the 20th Century

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Robert V. Stick is a carbohydrate chemist; and so am I. Carbohydrate chemistry is a special branch of organic chemistry. The carbohydrates differ from the common organic chemicals in many ways: they do not dissolve in organic solvents, they cannot be distilled; and when a pure sugar is dissolved in water, a solution results that contains six different compounds. Carbohydrate chemists have their own journals and textbooks.

Carbohydrate chemistry did not develop until the end of the 19th century; then Emil Fischer[1] determined the structures and configuration of all the simple sugars, established conversions, and studied their reactions. I worked for my Ph.D. degree in sugar chemistry with Zemplén, a former student of Fischer; he was not a brilliant chemist, and was a poor supervisor. When I completed my degree, I decided not to work on sugars any more: I thought that the problems there had already been solved by Fischer himself and his team. I went into the pharmaceutical industry.

But soon I realised that my judgment was not right: there was plenty to learn still about the properties of sugars. Thus, we did not know why D-glucose is mainly in the β-pyranose form but D-mannose mainly the α-pyranose. Why does the equilibrium of D-glucose contains very little furanose but that of D-idose quite a lot? Why do some sugars readily form a 1,6-anhydride but others do not? When I obtained a university position in 1946, I returned to carbohydrate chemistry.

In the middle of the century, three new methods revolutionized carbohydrate chemistry: NMR spectroscopy,[2] X-ray crystallography,[3] and conformational analysis.[4] NMR spectroscopy allowed the determination of the exact proportions of isomers in equilibrium; the X-ray method indicated the exact shapes of the molecules; and conformational analysis supplied the explanations and allowed predictions of behaviour. It became now much easier to deal with the structures and synthesis of complex carbohydrates, such as oligosaccharides and glycosides.

And synthesis has been improved by new methods and new reagents, and by better control of conditions. Separation methods were also improved, for example chromatography – originally an analytical technique – was turned into an efficient method of preparative separation. When Stick established his group in the Department of Chemistry at the University of Western Australia his collaborators and Ph.D. students carried out a range of reactions with a variety of sugars. Many of the compounds thus obtained were natural products, but others were artefacts. These, of course, were compounds of interest to biochemists because they could be tested for potential biological activity.

Soon many papers appeared on the biochemical behaviour of sugar derivatives. By now, there were biochemists in some chemistry departments and chemists in some biochemistry departments. Ideally, close cooperation was desired between them but, in fact, was seldom achieved. In most universities, the chemistry and the biochemistry departments are in different faculties and not even close to each other. [In my case, the two schools do not even inform each other of their seminars.] By contrast, by the time of the retirement of Robert Stick in 2008, his department had been renamed the School of Biomedical, Biomolecular and Chemical Sciences.

The changes in carbohydrate chemistry are easily surveyed by looking at two sources of information: the series *Advances in Carbohydrate Chemistry*, published annually since 1945, and the programs of the International Symposia on Carbohydrate Chemistry, held biennially since 1960. The *Advances* contain chapters of current interest on carbohydrates; the symposia consist of talks on subjects in which work was currently carried out. Both indicate which way carbohydrate research is moving. Both organizations realised how much it was tending towards biochemistry. In 1989 *Advances in Carbohydrate Chemistry* added the words 'and Biochemistry' to its title; in 1980, the Symposia made room for biochemistry in the opposite way by omitting in Vancouver the word 'Chemistry' and becoming International Carbohydrate Symposia. Neither of these bodies used the term 'Glycoscience', much liked by some of the biochemists. [However, a recent book on carbohydrate chemistry and biochemistry is entitled *Glycoscience; Chemistry and Chemical Biology*. It contains more than 9000 references!]

At the Symposium in Hamburg (in 2000), about one-third of the presented papers and the posters were on biochemistry and biotechnology. By then, interest in carbohydrates had grown very much: there were almost 1000 talks and posters presented. At the latest Symposium, in 2007 in Oslo, again about one-third of the papers and posters were on biochemical subjects. Curiously, the proportion was smaller for the plenary and invited lectures; apparently there were few biochemists on the organizing committee. Unfortunately, Robert Stick missed this meeting, his first absence in over 20 years.

All this development affected Robert Stick's interest and research too. Most of his work was published in the *Australian Journal of Chemistry* but gradually shifted to journals of

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biological or technical interest. His first paper in *Biochemistry Journal* appeared in 1986; after 2000 his biochemical papers became more frequent. Increasingly his overseas visits took him to places with biochemical interests.

It is hoped that after his retirement from his chair in Perth, Robert Stick will continue to carry out his interesting work in carbohydrate chemistry and biochemistry, mainly overseas. We wish him much success.

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