Molecular Structure of Carbohydrates

THE British Association discussion at Norwich on September 5, in Section B (Chemistry), on the molecular structure of carbohydrates, following the presidential address to the section, revealed both the variety of the important problems which still await solution, and the diversity of methods now employed in the attack on these problems. The discussion was opened by Prof. W. N. Haworth, president of Section B, whose presidential address constituted a survey of the present position of polysaccharide chemistry. It was shown that the recognition of the pyranose structure of ordinary glucose —a discovery barely ten years old—led the way in the elucidation of the ring structures of the disaccharides and afterwards of the polysaccharides.

Cellobiose (4–β–glucopyranosido-glucopyranose) and maltose (4–α–glucopyranosido-glucopyranose) are of special importance respectively in the chemistry of cellulose and of starch. Both these polysaccharides consist essentially of chains of glucopyranose units linked through positions 1 and 4, the glucosidic link being α– in starch and β– in cellulose. Chains of glucopyranose units appear also in glycogen and in lichenin. In xylan there occur chains of β–xylopyranose residues; and chains of manno-pyranose units (mutually linked through positions 1 and 6) and galactopyranose units (linked through positions 1 and 4) occur in polysaccharides synthesised *in vivo* by the action of certain moulds on glucose solutions. All the above are of the pyranose type, but the furanose structure is also found in polysaccharides, and recent work shows that its occurrence is widespread. An arabofuranose unit forms the terminal portion of the xylan molecule; chains of fructofuranose units with mutual linkages in the 1 : 2 positions constitute inulin, whereas fructofuranose units linked through positions 2 and 6 are found in levan, an important bacterial polysaccharide, and in a closely related polysaccharide which occurs in grass.

The work of the Birmingham school has, however, gone beyond the elucidation of the molecular structures of the polysaccharides and has succeeded in determining by purely chemical methods the molecular size of the giant molecules. For example, by gravimetric assay of the tetramethyl glucose formed on hydrolysis of the fully methylated polysaccharide, the chain-length of methylated cellulose has been fixed at 100–200 glucose units, and that of starches of diverse botanical origin at 26–30 units. Use of this 'end-group' method has served for the allocation of chain-lengths to glycogen, xylan, inulin, levan, and other polysaccharides. In many examples, this chemical molecular weight is in striking disagreement with the figure obtained on the basis of Staudinger's viscosity method, and the causes for this divergence were discussed with particular reference to the important case of the amylose and amylopectin constituents of starch, in which aggregation of the macro-molecules takes place. Special emphasis was laid on the need for clear differentiation between the chemical molecule and aggregates of such molecules which function as physical units.

Other methods of attack on the problem of molecular weights are also being employed, and in a subsequent paper Dr. S. R. Carter described results of osmotic pressure measurements on methylated and acetylated derivatives of inulin and lichenin. One of the principal difficulties in the use of this method lies in the choice of suitable semipermeable membranes, but by use of a disc of 'viscacelle' of adjusted porosity in specially designed apparatus, accurate measurements of osmotic pressure were obtainable. The figures for inulin were of particular interest, since they are in complete agreement with the chemically determined chain length (30 fructose units), whereas the viscosimetric measurements indicated only one-third of this value (10 units). In this case the failure of the viscosity method may be connected with the special conformation of the fructose units in the polysaccharide molecule.

Prof. Haworth's address concluded with a reference to investigations which have been commenced on the constitution of plant gums. These are of particular interest in that a derivative of gum arabic is known to possess properties resembling those of the specific polysaccharide of Type III pneumococcus anti-serum. The recent discoveries of such polysaccharides having immunological properties are of great importance, and the elucidation of the chemical structure of these substances must be of the greatest possible service to medicine.

In the paper which followed, Dr. W. T. J. Morgan discussed the function of polysaccharides in immunological specificity. He described the early discoveries concerning the specific precipitant for pneumococcus antibacterial immune serum, which led to the recognition that the capsular substance, different for each kind of bacterium, contains a complex polysaccharide which is the specific agent responsible for the serological reactions of the organism with the homologous antibody. Considerable progress is being made in inquiries into the chemical location of the specific characteristics, and it appears that the latter depend upon (*a*) the nature and stereochemical arrangement of the component sugars; (*b*) the mode of linkage of the sugar residues; and (*c*) the nature and position of substituent groups in the sugar residues. The mode of combination by which the reducing group of a glycuronic acid molecule forms a glycosidic union with the terminal primary alcoholic group of a glucose (or galactose) molecule, appears to have special significance in immunological chemistry. In addition, the specific properties of the polysaccharide-protein complex are closely governed by the presence in the polysaccharide of appropriately situated substituent groups, such as acetyl.

The two remaining papers were concerned with the intimate structure of the simple sugars. Dr. E. L. Hirst considered the possible correlation of structure with optical rotatory power in the sugar group. Although many empirical rules relating structure and rotation have been enunciated, their validity is always severely restricted to a small group of substances, and exceptions are frequent. It was shown that measurements of the rotatory power in the ultra-violet region of the spectrum sometimes give clues to the causes of departures from the rotation-rules. Three typical problems were discussed. (*a*) The abnormal rotations in the mannose series of

sugars were found to be ascribable entirely to the mutual influence of the two *cis* hydroxy groups on C_2 and C_3. (*b*) The negative rotations of tetramethyl γ-mannonolactone in organic solvents were explained by the nature of the rotatory dispersion, which requires for its representation a two-term Drude equation with terms of opposite sign, the induced term being positive both in water (where the lactone rule is obeyed) and in organic solvents. (*c*) The sign of the induced term in the rotations of amides can be correlated with the configuration of C_2 for those substances which obey the amide-rule, but exceptions occur which necessitate special explanations.

Mr. E. G. Cox gave an account of recent progress in the crystallography of carbohydrates. X-ray studies of a number of simple and methylated sugars lead to the conclusion that the six-atom ring in the pyranoses, unlike the hexamethylene ring, does not possess the Sachse form, but contains five nearly co-planar carbon atoms, the oxygen atom being displaced out of their plane. Various chemical and physical properties of carbohydrates find a satisfactory explanation in terms of this ring conformation; for example, there is much evidence that hydroxyl groups which, according to the Haworth structural formulæ, are *cis*, are actually contiguous in space. This is true for the ring form deduced from the X-ray data, but it is by no means necessarily so with a Sachse ring.

The configuration on the first carbon atom of the cyclic forms of the sugars is not established by the same rigid methods which are applied to the remainder of the molecule; the confirmation by X-ray methods of the configurations usually ascribed to the α- and β-forms of glucose is therefore a matter of considerable importance.

Educational Topics and Events

CAMBRIDGE.—At Emmanuel College, Dr. T. S. Hele, fellow of the College and University lecturer in biochemistry, has been elected into the mastership.

A. C. Bartlett, of Emmanuel College, has been approved for the degree of Sc.D.

P. H. Blair, of Emmanuel College, has been appointed an assistant lecturer in archæology and anthropology.

EDINBURGH.—The Rockefeller Foundation has made a grant of £1,500 to the Department of Medical Chemistry, to provide for the expenses of Prof. Barger's research work on vitamin B_1, for a period of three years from October 1935.

It has been agreed to offer accommodation in the University for the meeting of the International Union of Geodesy and Geophysics, which is to take place in Edinburgh on September 15–26, 1936.

SHEFFIELD.—The following appointments have recently been made: Prof. C. J. Patten, formerly professor of anatomy, and Prof. Miles H. Phillips, formerly professor of obstetrics and gynæcology, as emeritus professors; Dr. H. A. Krebs, as lecturer in pharmacology; Mr. H. E. Collins, as lecturer in mining; Dr. M. Ritchie, as assistant lecturer in chemistry; Mr. J. Harwood, as research assistant in fuel technology; Dr. J. W. Rodgers, as Ironmongers' Company research fellow (for one year).

Science News a Century Ago

Meeting of the Medico-Botanical Society

THE first general meeting of the session for 1835–36 of the Medico-Botanical Society was held on November 10, Earl Stanhope being in the chair. After the reading by Dr. Sigmond of an eulogium on the character of the late Gilbert Burnett, professor of botany to the Society, Mr. C. Johnson delivered a lecture on the importance of botany to medicine. He contrasted the present knowledge with that of the practitioner of former days, and dwelt on the necessity of giving to the vendor of drugs an education superior to what they had and of making the study of botany indispensable.

The Paris to St. Germain Railway

THE first railway to be authorised in France was that from Paris to St. Germain, and on November 14, 1835, the *Athenæum* said of this line that it "is to commence near the Church de la Madelaine on the Boulevards, and afterwards pass through a tunnel under the Commune of Les Batignolles Monceaux. This tunnel will be 907 yards in length. There are to be three stations for receiving and delivering luggage. The number of bridges or viaducts to be erected over streets and roads, between the point of departure and the Seine will be twelve. Altogether, it is considered that this railroad will be one of the best constructed, and most useful of any yet projected, not excepting those now in progress in England. It is expected, that the steam carriages on this road will be able to travel at the rate of thirty miles an hour, and according to this calculation, the distance between Paris and St. Germain will be performed in twenty-four minutes. It now occupies one hour and forty minutes."

Darwin at Tahiti

ON November 15, 1835, H.M.S. *Beagle* arrived at Tahiti, where she remained until November 26, when she sailed for New Zealand. Both Capt. FitzRoy and Darwin wrote interesting accounts of the island and its people, and Darwin said:

"I was pleased with nothing so much as with the inhabitants. There is a mildness in the expression of their countenances which at once banishes the idea of a savage; and an intelligence which shows they are advancing in civilisation. . . . On the whole, it appears to one that the morality and religion of the inhabitants are highly creditable." Of those who attacked the work of the missionaries among the islanders and its effect, he said: "They forget, or will not remember, that human sacrifices, and the power of an idolatrous priesthood—a system of profligacy unparalleled in any other part of the world—infanticide a consequence of that system—bloody wars, where the conquerors spared neither women nor children—that all these have been abolished; and that dishonesty, intemperance, and licentiousness have been greatly reduced by the introduction of Christianity. In a voyager to forget these things is base ingratitude. . . ."

On November 26, when the ship sailed, Darwin wrote: "In the evening, with a gentle land-breeze, a course was steered for New Zealand; and as the sun set, we had a farewell view of the mountains of Tahiti—the island to which every voyager has offered up his tribute of admiration."