legitimate field; nor will I discuss the much argued question as to whether we should cease to be one of the nations for which the metric system is only "facultatif", and join the majority for which it is "obligatoire". Britishers do not like being *compelled* to do things—but I am sure that we will eventually all use the standards of the C.G.S. system, and employ its units exclusively, before your generation passes. It has been in use now some 135 years. It has been an International System, with national standards distributed, for but 45 years; yet to-day there are 31 countries members of the Convention, representing populations of 750 million people, of whom nearly 600 millions employ the C.G.S. Standards as those of their national system. Many of the remaining millions make more use of the C.G.S. system than of any other; that applies particularly to scientists throughout the world.

Later, I will arrange for an article, by an authority on such matters, on the Comparison of Measures.

CARBOHYDRATES AND THEIR CHEMISTRY.

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We eat them, we wear them, we sit and stand on them, we write on them and even make some of our most popular drinks from them. Wheat and other cereals contain starch, a carbohydrate; sugar is also a carbohydrate; cotton, linen and other textiles of vegetable origin contain large proportions of the carbohydrate cellulose; cellulose is also found in wood.

The isolation of cellulose from wood in a more or less uncontaminated condition is the first stage in the manufacture of much of our paper, and cellulose so obtained often forms the raw material from which, by chemical processes, artificial silk, lacquers, films and other common commodities are made. The carbohydrates are also the basis of the fermentation industries, leading not only to alcoholic beverages but also to a variety of useful solvents, such as butanol, butyl acetate, acetone, and so on.

So that the carbohydrates should be of interest to any ordinary citizen who thinks of what he eats, drinks, wears and uses. The trouble is that the chemistry of this group falls into the division of the subject usually known as "organic", while "inorganic" chemistry is considered to be the only branch suitable for study in schools. Also, there is no denying that the molecules of the carbohydrates are large and complicated. For instance, glucose, which is one of the simpler carbohydrates, has a molecular formula $C_6H_{12}O_6$. The possible arrangements in a molecule of 24 atoms are multitudinous, and if we had not a certain amount of guidance from a detailed knowledge of a large number of other carbon compounds the task of considering the exact chemical nature of glucose would be very difficult.

There is, however, one important aspect of carbohydrate chemistry which can be understood quite easily without worrying about the inside structure of the glucose molecule. This is the relationship existing between the various members of the group.

Cellulose and starch are substances of which the individual molecules are very large. The formulæ are usually written $(C_6H_{10}O_5)_n$ where n is not exactly known, but is believed to be about 30 for starch and about 200 for cellulose. On treatment with acids under appropriate conditions, both cellulose and starch break down quantitatively to glucose by a process of hydrolysis or chemical addition of water:

$$(C_6H_{10}O_5)_n + nH_2O \longrightarrow nC_6H_{12}O_6$$

This reaction is much more easily realised with starch than with cellulose, and is the basis of the commercial manufacture of glucose. Very often maize starch is used as the raw material, and heating with a very small quantity of dilute sulphuric or other acid is sufficient to accomplish the hydrolysis. The product is usually a thick syrup and contains dextrins, carbohydrates intermediate in complexity between starch and glucose, as well as glucose itself.

Cane sugar has the molecular formula $C_{12}H_{22}O_{11}$ and on hydrolysis with dilute acid yields glucose and another sugar of the same composition, fructose, in which there is a slightly different arrangement of atoms within the molecule.

$$C_{12}H_{22}O_{11} + H_2O \longrightarrow C_6H_{12}O_6 + C_6H_{12}O_6$$

This is sufficient to show that the carbohydrates as a group are closely related to one another. In systematic nomenclature the more complex ones are called polysaccharides, cane sugar is a disaccharide, and glucose and fructose monosaccharides.

There are many other carbohydrates of each class, but those already mentioned are sufficient to illustrate the type of relationship which exists between them.

Perhaps the most important of the carbohydrates from a chemical point of view is cellulose since it forms the starting material of so many industries. Explosives, textiles, paints and paper are all to be included among cellulose products. Artificial silk has nowadays become so widely used that attention may be directed to it as a characteristic cellulose product.

The silkworm makes its silk by ejecting a viscous fluid through fine orifices, and on exposure to the air the issuing stream of fluid hardens, so forming a continuous filament of silk. The artificial silk manufacturer has before him the problem of converting his raw material into a viscous fluid, forcing this through dies, and by some means re-solidifying the issuing stream of fluid.

Cellulose is not dissolved by water or by any of the common solvents. A simple solution of cellulose cannot be prepared. But certain substances will combine with cellulose to give products which are soluble in water or other solvents. For example, the deep blue solution formed when copper hydrate is dissolved in ammonia will take cellulose into solution on account of a chemical union between the copper, ammonia and the cellulose. The solution so formed is viscous, and from it the cellulose can be reprecipitated—naturally in an amorphous condition—by the addition of acids. So that if the solution is forced through fine dies and the issuing stream allowed to pass into an acid bath, a continuous filament of regenerated cellulose is formed. This was one of the earlier processes used for the manufacture of artificial silk, "the cuprammonium process."

A much more widely used process is the "viscose" process. When a strong solution of caustic soda is allowed to come into contact with cellulose some of the alkali actually combines with the cellulose. "Alkali-cellulose" so prepared will react very readily with carbon bisulphide to give a "viscose" or "cellulose xanthate" which will dissolve in water to a viscous solution. As

in the case of the cuprammonium solution, the cellulose can be precipitated by the use of suitable chemical reagents, either as a continuous filament suitable for artificial silk or as a transparent film of the type which is largely used as a wrapping material. Such regenerated cellulose is flexible and insoluble in water, like cotton.

Yet another artificial silk process, involving a slightly different principle, may be mentioned. Cellulose can be made to combine with acetic acid under proper conditions to give cellulose acetates which are soluble in various solvents. The commercial preparation leads to a product soluble in the solvent acetone to a viscous solution, and from which the acetone may be evaporated to leave the cellulose acetate as a transparent film. A thin stream of such a solution issuing into a hot-air chamber will be converted into a filament of cellulose acetate, which can be employed as artificial silk. In this case the silk does not consist of cellulose but of cellulose acetate—which still retains its property of dissolving in acetone.

The most widely used of these processes is the "viscose" process. Many difficulties had to be overcome before artificial silk could be manufactured on a large scale; for example the dyeing of artificial silk is a matter which has required very special attention, especially in the case of "acetate" silk.

The formation of the cellulose acetate depends upon the presence of OH (hydroxyl) groups in the cellulose molecule. Experience with a large range of carbon compounds has shown that the hydroxyl group is capable, under certain conditions, of reacting with acids to form substances known as "esters". Cellulose acetate is an ester of cellulose. Other acids also will form esters with cellulose. The cellulose nitrates formed by the esterification of cellulose with nitric acid are most important industrial products. Some of them are used as explosives (gun-cotton), others can by solution and evaporation of the solvent be obtained as films and so may be used for the manufacture of lacquers ("cellulose lacquers") as well as for transparent sheets (celluloid and collodion).

In the carbohydrate group, therefore, there is an attractive field for chemical study. In addition, the chemical processes by which plants build up carbohydrates from carbon dioxide and water are mysteriously fascinating and but imperfectly known.