If the asymmetric system adjoining the COH group, which is that introduced in synthesizing the hexose from the pentose, be eliminated, the formulae at disposal for the two pentoses are

CH2(OH)---COH

CH2(OH) + -- COH.

When such compounds are converted into corresponding dibasic acids, CO2H.[CH(OH)]2.C02H, the number of asymmetric carbon atoms becomes reduced from three to two, as the central carbon atom is then no longer associated with four, but with only three different radicles. Hence it follows that the “ optical ’’ formulae of the acids derived from two pentoses having the configuration given above will be

co2h-o-co2h co2h+o-co2h,

and that consequently only one of the acids will be optically active. As a matter of fact, only arabinose gives an active product on oxida­tion; it is therefore to be supposed that arabinose is the---

compound, and consequently

CH2(OH)---+ COH = *l*-glucose

CH2(OH) + COH = *l*-gulose.

When xylose is combined with hydrocyanic acid and the cyanide is hydrolysed, together with *l*-gulonic acid, a second isomeric acid, *l*-idonic acid, is produced, which on reduction yields the hexaldose *l*-idose. When *l*-gulonic acid is heated with pyridine, it is converted into *l*-idonic acid, and vice versa; and *l*-gulonic acid may in a similar manner be converted into *d*-idonic acid, from which it. is possible to prepare *l*-idose. It follows from the manner in which *l*-idose is produced that its configuration is CH2(OH) +---+ COH.

The remaining aldohexoses discovered by Fischer are derived from *d*-galactose from milk-sugar. When oxidized this aldohexose is first converted into the monobasic galactonic acid, and then into dibasic mucic acid; the latter is optically inactive, so that its configuration must be one of those given in the sixth and seventh columns of the table. On reduction it yields an inactive mixture of galactonic acids, some molecules being attacked at one end, as it were, and an equal number of others at the other. On reducing the lactone prepared from the inactive acid an inactive galactose is obtained from which Z-galactose may be separated by fermentation. Lastly, when *d*-galactonic acid is heated with pyridine, it is con­verted into talonic acid, which is reducible to talose, an isomeride bearing to galactose the same relation that mannose bears to glucose. It can be shown that *d*-galactose is CH2(OH)+-+-COH, and hence *d*-talose is CH2(OH) +-+ + COH.

The configurations of the penta-and tetra-aldoses have been determined by similar arguments; and those of the ketoses can be deduced from the aldoses.

*Disaccharoses.*

The disaccharoses have the formula C12H22O11 and are character­ized by yielding under suitable conditions two molecules of a hexose: C12H22O11 + H2O = C6H12O6+C6H12O6. The hexoses so obtained are not necessarily identical : thus cane sugar yields *d*-glucose and *d*-fructose (invert sugar); milk sugar and melibiose give *d*-glucose and *d*-galactose, whilst maltose yields only glucose. Chemically they appear to be ether anhydrides of the hexoses, the union being effected by the aldehyde or alcohol groups, and in consequence they are related to the ethers of glucose and other hexoses, *i.e.* to the alkyl glucosides. Cane sugar has no reducing power and does not form an hydrazone or osazone; the other varieties, however, reduce Fehling’s solution and form hydrazones and osazones, behaving as aldoses, *i.e.* as containing the group ∙CH(OH)∙CHO. The relation of the disaccharoses to the α- and *β*-glucosides was established by E. F. Armstrong *(Journ. Chem. Soc.,* 1903, 85, 1305), who showed that cane sugar and maltose were α-glucosides, and raffinose an α-glucoside of melibiose. These and other considera­tions have led to the proposal of an alkγlen oxide formula for glucose, first proposed by Tollens ; this view, which has been mainly developed by Armstrong and Fischer, has attained general acceptance (see Glucose and Glucoside). Fischer has proposed formulae for the important disaccharoses, and in conjunction with Armstrong devised a method for determining how the molecule was built up, by forming the osone of the sugar and hydrolysing, whereupon the hexosone obtained indicates the aldose part of the molecule. Lactose is thus found to be glucosido-galactose and melibiose a galactosido-glucose.

Several disaccharoses have been synthesized. By acting with hydrochloric acid on glucose Fischer obtained isomaltose, a disac­charose very similar to maltose but differing in being amorphous and unfermentable by yeast. Also Marchlewski (in 1899) synthe­sized cane sugar from potassium fructosate and acetochloro-glucose; and after Fischer discovered that acetochlorohexoses readily resulted from the interaction of the hexose penta-acetates and liquid hydrogen chloride, several others have been obtained.

Cane sugar, saccharose or saccharobiose, is the most important sugar; its manufacture is treated below. When slowly crystallized it forms large monoclinic prisms which are readily soluble in water but difficultly soluble in alcohol. It melts at 160o, and on cooling solidifies to a glassy mass, which on standing gradually becomes opaque and crystalline. When heated to about 200’ it yields a brown amorphous substance, named caramel, used in colouring liquors, &c. Concentrated sulphuric acid gives a black carbon­aceous mass; boiling nitric acid oxidizes it to *d*-saccharic, tartaric and oxalic acids; and when heated to 16o° with acetic anhydride an octa-acetyl ester is produced. Like glucose it gives saccharates with lime, baryta and strontia.

Milk sugar, lactose, lactobiose, C12H22O11, found in the milk of mammals, in the amniotic liquid of cows, and as a pathological secretion,. is prepared by evaporating whey and purifying the sugar which separates by crystallization. It forms hard white rhombic prisms (with 1H2O), which become anhydrous at 140°and melt with, decomposition at 205°. It reduces ammoniacal silver solutions in the cold, and alkaline copper solutions on boiling. Its aqueous solution has a faint sweet taste, and is dextro-rotatory, the. rotation of a fresh solution being about twice that of an old one. It is difficultly fermented by yeast, but readily by the lactic acid bacillus. It is. oxidized by nitric acid to *d*-saccharic and mucic acids ; and acetic anhydride gives an octa-acetate.

Maltose,, malt-sugar, maltobiose, C12H22O11, is formed, together with dextrine, by the action of malt diastase on starch, and as an intermediate product in the decomposition of starch by sulphuric acid, and of glycogen by ferments. It forms hard crystalline crusts (with 1H2O) made up of hard white needles.

Less important disaccharoses are: Trehalose or mycose, C12H22O11∙2H20, found, in various fungi, e.g. *Boletus edulis,* in the Oriental *Trehala* and in ergot of the; melibiose, C12H22O11, formed, with fructose, on hydrolysing the trisaccharose melitose (or raffinose), C18H32O16∙5H2O, which occurs in Australian manna and in the molasses of sugar manufacture; touranose, C12H22O11, formed with *d*-glucose and galactose on hydrolysing another trisaccharose, melizitose, C18H32O16∙2H2O, which occurs in *Finns larix* and in Persian manna; and agavose, C12H22O11, found in the stalks of *Agave americana.* (X.)

Sugar Manufacture

*Sugar-cane* is a member of the grass family, known botani- cally as *Saccharum officinarum,* the succulent stems of which are the source of cane sugar. It is a tall perennial grass-like plant, giving off numerous erect stems 6 to 12 ft. or more in height from a thick solid jointed root-stock. The stems are solid and marked with numerous shining, polished, yellow, purple or striped joints, 3 in. or less in length, and about 11/2 in. thick. They are unbranched and bear in the upper portion numerous long narrow grass-like leaves arranged in two rows; the leaf springs from a large sheath and has a more or less spreading blade 3 ft. in length or longer, and 3 in. or more wide. The small flowers or spikelets are borne in pairs on the ultimate branches of a much branched feathery plume-like terminal grey inflorescence, 2 ft. or more long. Production of flowers is uncertain under cultivation and seed is formed very rarely. The plant is readily propagated by cuttings, a piece of the stem bearing buds at its nodes will root rapidly when placed in sufficiently moist ground. The sugar-cane is widely cul­tivated in the tropics and some sub-tropical countries, but is not known as a wild plant. Its native country is unknown, but it probably originated in India or some parts of eastern tropical Asia where it has been cultivated from great antiquity and whence its cultivation spread westwards and eastwards. Alphonse de Candolle *(Origin of Cultivated Plants,* p. 158) points out that the epoch of its introduction into different countries agrees with the idea that its origin was in India, Cochin-China or the Malay Archipelago, and regards it as most probable that its primitive range extended from Bengal to Cochin-China. The sugar-cane was introduced by the Arabs in the middle ages into Egypt, Sicily and the south of Spain where it flourished until the abundance of sugar in the colonies caused its cultivation to be abandoned. Dorn Enrique, Infante of Portugal, surnamed the Navigator (1394-1460) transported it about 1420, from Cyprus and Sicily to Madeira, whence it was taken to the Canaries in 1503, and thence to Brazil and Hayti early in the 16th century, whence it spread to Mexico, Cuba, Guadeloupe and Martinique, and later to Bourbon. It was introduced into Barbadoes from Brazil in 1641, and was dis­tributed from there to other West Indian islands. Though cultivated in sub-tropical countries such as Natal and the Southern states of the Union, it is essentially tropical in its requirements and succeeds best in warm damp climates such as