THE CHEMICAL NATURE OF COTTON.

BY E. DWIGHT KENDALL.

Cellular filaments, turgid with nutrient and astringent juices, springing from the nearly ripened seed and intertwining in a seeming tangled mass; soon lengthing and becoming hard and ligneous; then the remnant of the sap dries up within them, and they shrivel to flattened, twisted, sear (and sometimes yellow), lifeless—*cotton fibres*.

The chemistry of cotton began with the art of dyeing, in India; the ancient Egyptians were skilled in dyeing *al-quton:* they were not required to reconcile the cotton with coal-tar colors. A knowledge of the physical structure and chemical constitution of the cotton fibre does not explain its indifference to most dyes, nor can its affinity for a certain few coloring matters be understood, because it does not appear to form chemical combinations with these: they can be readily removed, leaving the fibre unchanged.

The ripe fruit of the cotton-plant (Gossypium, from the Arabic *goz*, a soft substance) is a large capsule containing a mass of the filaments, which envelop and adhere to the seeds. The fibres from different species of the plant vary in length, thickness, flexibility, tensile strength, and color; the diameters are from $\frac{1}{800}$ to $\frac{1}{2500}$ of an inch, and the lengths from 0·77 to 1·80 inches; the mean diameter of Sea Island cotton fibres is $\frac{1}{1562}$ of an inch and the average length 1·60 inches; some cottons are highly colored, like the so-called *Nankin*, and the whitest contains some natural coloring matter, which is of the same character in all cottons, and consists of two bodies, one freely soluble in alcohol, the other not.

Clean cotton is nearly pure *cellulose;* the associated substances are in varying and exceedingly small proportion, and may be removed by means of hot alkalies, dilute acids, and ether; the bodies obtained by this treatment are found to consist of waxy, albuminoid, and coloring matters; ulmic, pectic, and fatty acids; calcium and sodium sulphates; and ferric, silicic, and aluminium oxides, with traces of potash and magnesium phosphate. The ulmic acid perhaps results from the action of the chemical agents on woody tissue (not cellulose), and in like manner the pectic acid may be formed from insoluble pectose.

Cellulose is the principal material in the structure of plants; the natural process of its formation and its relations to allied bodies constitute one of the most interesting studies in science. The formula of pure cellulose is $C_6H_{10}O_5$, or $C_{18}H_{30}O_{15}$; therefore it is composed of carbon and the elements of water, or, empirically, it may be said to consist of carbon and water. It is isomeric with dextrine and starch, and differs from natural gum and the sugars (glucoses and saccharoses) only in the relative quantities of water elements. By simple chemical means cellulose may be changed to gum, to starch, and to sugar; by natural process the plant converts starch, gum, and sugar one into the other or into cellulose, according to the requirements of its different parts.

Are these changes produced simply by alteration of molecular structure? "The theory of atomicity . . . interprets the most complicated cases of isomerism"—with exceptions. We know that the vital principle of the plant directs the formation of tubes of cellulose, as conduits of the sweet sap from which they are produced; that the same saccharine juice deposits gum and, in the seed, starch, and that this starch, in the new growth, by the stimulation of diastase, changes itself to the forms of gum, and sugar, and cellulose, exhibiting in matter phenomena that suggest the convertibility of the different forms of energy; but we cannot explain these transmutations, nor do we understand why the presence of a small quantity of acid should convert a handful of old rags into an equal weight of sugar.

How do plants produce these bodies, composed of carbon with hydrogen and oxygen in the same relative proportions as in water? The hydrogen can only come from water; the plant obtains that through its roots, and as it does not receive oxygen from the air, water may also furnish that element, while, under the influence of light, the leaves absorb carbon dioxide, the source of the carbon.

The plant now has water and carbon from which to form its starch, gum, sugar, and cellulose. By resolution of the carbon dioxide and directly combining carbon and water? The process of eremacausis, or natural decay of woody fibre, would indicate this. It consists essentially in evolution of water and oxidation of carbon, with reproduction of carbon dioxide. But another consideration forbids this view. Not only do plants form bodies composed of carbon, hydrogen, and oxygen, but they also produce waxes, caoutchouc, essential oils, and resins, consisting of carbon and hydrogen, and containing little or no oxygen; therefore the plant must have the power to decompose water, and appropriate only the hydrogen. Hence it seems possible that the cellulose and allied bodies are produced by the combination of hydrogen from water with carbon dioxide, the oxygen of the water being emitted.

Although cellulose is so readily convertible to gum, starch, and sugar, it resists chemical action in the stomach, and is as innutritious as clay. It is scarcely attacked by dilute acids and alkalies, but strong sulphuric acid and zinc chloride change its physical character; "parchment paper" and "vulcanized fibre" are respectively produced by these agents. A solvent of cellulose is obtainable by dissolving cupric carbonate (formed by precipitation from the sulphate) in ammonia; it easily dissolves cotton, particularly so-called "absorbent cotton," and acids precipitate the cellulose in flocculent form.

Remarkable changes are effected in the nature of cellulose or cotton by the action of concentrated nitric or mixed nitric and sulphuric acids; hydrogen is removed, and the radical nitryl (NO_2) substituted, with formation of pyroxylins or varieties of nitro-cellulose. True "gun-cotton," or trinitrocellulose, $C_6H_7(NO_2)_3O_5$, is made with the more concentrated acids, while acids containing more water yield less highly nitrated or "soluble" proxylins, which are used in the manufacture of collodion, celluloid, zylonite, etc. To determine whether the alteration of structure and chemical nature of the cotton fibre had developed affinity for aniline colors, a few tests were made with pyroxylins; ordinary rosaniline dyes were used, and the trisulphoacid of rosaniline (Holliday's acid magenta); the trinitrocellulose rejected the dyes, while the partially nitrated cotton retained the colors after washing with soap and water.

A way to make cotton receptive of colors, without the use of mordants, and means of rendering it less combustible, of removing the harshness of inferior grades, and of bleaching it cheaply without injury to the fibre are desiderata that have engaged the attention of many chemists. An increased affinity for dyes may be imparted by preparatory treatment with hot dilute alkali, which removes most of the waxy and fatty matters, and notably alters the shape and dimensions of the fibre; it contracts in length, and approximates to the form of a simple round tube, with a clear hollow from end to end.

Cotton may be distinguished from other vegetable fibres, such as flax and hemp, with the microscope, and from wool and silk by simple chemical tests; for example: hot dilute alkaline solution does not affect cotton, but quickly dissolves the animal products; a solution of the trinitrophenol picric acid dyes wool and silk a permanent yellow, but washes away from cotton, leaving it white; or instead of the dye, dilute nitric acid may be used, which produces picric acid from the animal substance; a hot solution of mercuric nitrate imparts a red color to wool and silk, but leaves the cotton unchanged; by boiling cotton with dilute hydrochloric acid it becomes rotten, while wool and silk are not thereby changed; a solution of lead monoxide in dilute alkali blackens wool, but not cotton; a solution of zinc chloride dissolves away silk from cellulose, etc.

A remarkable fact respecting cellulose is its production in the animal economy: it has been found in skins of the silk worm and serpents.

Magnitude of the New Orleans Exposition.

Director-General Bourke, with the view principally of obtaining a further government appropriation for carrying on the great Exposition at New Orleans, has recently made a report of the receipts and expenses, and showing the magnitude of the enterprise. It appears that up to January 27, owing to bad weather and the incomplete condition of the Exposition, the receipts were smaller by five to ten thousand dollars a day than had been expected, and thus the management became burdened with a deficit which reached more than $300,000. Since that date it is reported that the receipts have been equal to the disbursements.

There are on the grounds fifteen buildings erected by the management, covering an area, in square feet, as follows:

Main building	1,656,000
Government and State Exhibitbuilding	648,825
Six live stockbarns	136,080
Horticultural Hall	116,400
Iron machinery extension	42,000
Iron sawmill building	36,000
Iron boiler house	28,000
Iron art gallery	25,000
Iron wagon building	24,000
Iron, brick, and tile building	12,000
Eight ornamental entrances }	
Three police buildings }	
One drainage station }	12,000
One waterwork station }	
One electric light building }	
Total area covered	2,726,305

In addition to the buildings constructed by the management, there have been erected upon the grounds: Mexican Commission and Headquarters building; Mexican building for mineral exhibit; two Public Comfort buildings; one Bankers' building; one Furniture Pavilion; one Terra Cotta Exhibit building; and ten structures of various sizes by individuals, aggregating 120,000 square feet, and making a total area of space covered by roof of 2,820,000 square feet. Six of the buildings constructed by the management are covered with iron, one principally with glass, and the remainder, embracing the principal buildings, are of Southern pine.

It thus appears, according to the official report, that the two main buildings of the Exposition cover a combined area of 2,304,825 square feet, or a greater area than was covered by the main buildings of the London Exhibition of 1862, Paris of 1878, Vienna of 1873 combined, or a larger area than the main buildings of the London Exhibition of 1862, say 1,400,000 square feet, and the Centennial of 1876, 876,206 square feet, combined. The area covered by the buildings erected by the management equals, it is said, the entire exhibiting area covered by all the buildings erected at the Centennial by the Centennial Commission, U. S. Government, foreign Governments, States, and Territories, and at less than one-fifth the cost.

The machinery plant or motive power of the exhibition is believed the largest ever collected, footing up 5,937 horse power, of which 1,900 horse power is required for the electric light part of the display. The engines furnishing this power are as follows:

	Horse Power.
Harris-Corliss engine, 30 x 72	650
Reynolds-Corliss, 32 x 60	600
Brown, 28 x 60	400
Wetherell-Corliss, 24 x 48	350
Wheelock, 24 x 48	300
Estes, 20 x 36	336
Taylor, 18 x 24	125
Buckeye, 15 x 27	150
Payne, 16 x 28	150
Lane & Bodley Corliss, 16 x 42	125
Reading Iron Works	150
Atlas	65
Six Westinghouse	146
Seven Armington & Sims	635
Armington & Sims	40
Four New York Safety	200
Russell	50
Ball	60
Westinghouse	150
Smith, Meyers & Snier	200
Fulton Iron Works	125
Allis	200
Stearns	200
Taylor	75
Bocage—Pine Bluff	50
Lane & Bodley	50
Russell	30
Salem	30
Erie	20
Harris-Corliss, Government building	150
Russell Planing Mill	25
Hewes & Phillips	100
Total	5,937

The electric light plant consists of: Seventy-three dynamos; four thousand Edison incandescent lamps; eight hundred Louisiana Electric Light Company's arc lamps; and five 36,000 candle power lights; three hundred Brush arc lamps; one hundred and forty Thompson & Houston arc lamps; and one hundred and forty Jenny arc lamps with five towers.

Foreign countries occupy the following amount of space allotted in the center of the Main building, viz.:

	Square Feet.
Austria-Hungary	16,008
Brazil	612
China	3,072
France	28,848
Great Britain	16,008
Honduras	2,184
Jamaica	1,632
Mexico	36,852
Sandwich Islands	576
Siam	576
Venezuela	576
Belgium	28,508
British Honduras	2,304
Costa Rica	672
Germany	5,412
Guatemala	1,440
Italy	8,671
Japan	6,720
Russia	16,508
San Salvador	288
Spain	1,440

Other exhibits are grouped as follows, viz:

	Square Feet.
Machinery exhibits	455,400
General exhibits	413,400
Furniture exhibits	34,200
Carriage exhibits	52,364
Art furniture and decoration	86,300
Mills	36,000
Machine tools	42,000
Textile exhibits	61,344
Food products exhibits—manufactured	68,660
Educational exhibits—commercial	31,672
Manufactures of metals	43,672

The main building and extensions are filled with exhibits, and twelve hundred applicants were refused because of a want of space, notwithstanding the fact that several additional buildings were erected or put under construction after it was discovered in November that the extensive buildings previously constructed were utterly inadequate. Large quantities of machinery and other exhibits, for which no space can be found, remain at New Orleans, awaiting the possibility of additional buildings or the completion of those begun. Work has been discontinued on newly designed buildings not completed, owing to lack of funds.

Cancer in Horses.

The *Indian Medical Gazette* says: *Melanotic cancer* is an ordinary cause of death in Bengal among gray and white horses. We can scarcely drive through Calcutta without seeing animals having the characteristic globular tumors beneath the skin.