THE WORLD'S SUGAR SUPPLY.*

SUGAR CANE AND BEET.

BY GEORGE T. SURFACE, PH.D.

THE problem of sweetening humanity physically is only second to that of sweetening it temperamentally and socially. What was an efficacious medicine prior to the tenth century became through the increased quantity and the cultivated taste a delicate luxury from the tenth to the sixteenth century; and thereafter began to be a staple food in certain parts of the world. In medieval times the peasants could only partake of sugar occasionally at special feasts, and the privilege was so coveted as to make the sugar-eating days loom up as bright spots on the mental horizon to lighten the burden of grinding poverty and every-day toil. The sixteenth century ushered in a new epoch of industrial development in which sugar was destined to play the most conspicuous part during at least a century. The islands of the West Indies and the tropical coasts of the Americas seemed to be but waiting for the transplanting of the cane and the introduction of the negro. The sugar industry and the slave traffic fitted into each other so perfectly, that throughout the colonial exploitation of slavery the sugar industry was without a peer in the international trade. As late as 1830, more than half of the world's sugar crop was produced by slave labor, and with the emancipation of slavery the tropical sugar industry suffered a depression from which it did not rise until it rose to find a dangerous competitor in the sugar beet of the temperate zone.

The sugar production of the world continues to increase more rapidly each year, and yet the demand is economically greater than the supply. During the past quarter century the world's production has been doubled. In 1888, the total production of all countries was 7½ million tons and in 1908, the production was more than 14 million tons. In this interval the per capita consumption in the United States rose from 50 pounds to 83 pounds, an increase of 65 per cent. The only country exceeding the United States in the great sugar-eating contest is Great Britain, whose record last year was almost 90 pounds for each man, woman and child. The enormous consumption of sugar in these two countries presents the anomaly of comparatively small producers being the largest consumers. It must be remembered, however, that the taste for sugar is far more natural than acquired, and intensifies itself with the ability to pay the price. Denmark and Switzerland are the only other countries of Europe consuming as much as 50 pounds per head, and the general average for all Europe is about 24 pounds per head. Germany, the greatest sugar-producing country, consumes only 42 pounds per head; and Belgium, the little industrial giant of the continent, consumes only 24.4 pounds per head, which is 45 per cent less than the German consumption. The variation in the amount of sugar consumed in the same country and in different countries finds its explanation in the cost of the commodity, the wages of the consumer, and the native food-stuffs. The retail price of sugar in Naples and Milan is 13½ cents per pound, which is almost three times the London price; but the average wage of the unskilled laborer in Italy is but one-third to one-half that of the corresponding English laborer. In addition, the greatest poverty in Italy exists in the south, where the food must consist largely of sub-tropical fruits and vegetables in which sugar is an important constituent. We need not, therefore, be surprised at the fact that the average sugar consumption in Italy is 8.3 pounds per year, purchased at a cost of \$1.12, or four days' labor; while the more fortunate Englishman purchases with the same amount of labor, 75 pounds of sugar. The Austrians consumed only 24 pounds per year, but the retail price is 7 to 8 cents per pound, and the average wage less than one-third that of the Englishman, and one-quarter that of the American.

Poverty makes necessary the purchase of the cheapest foods to the end of supplying a sustaining quantity, and as starch foods are cheaper than sugar throughout the world, the poorest classes in all countries show their preference for them. It is a fortunate coincidence that a large consumption of starch foods makes a corresponding consumption of sugar unnecessary, since starch and sugar belong to the same chemical family. It is obvious that all classes with a sufficient income to purchase a diversity of foods consume more than the per capita average, and that the wealthiest are the largest consumers.

The phenomenal increase in the demand for sugar is in part attributable to a gradual change in the opinion of medical and scientific students concerning its

relative value as a food. When the medical profession was based upon one and two years of indifferent investigation, the idea generally prevailed that sugar was a dangerous, indigestible compound, and the specific cause of many fatal, organic diseases. To those who could not afford to purchase it, this was the most convenient excuse for a minimum consumption, and in many rural communities is as strenuously advocated to-day as it was fifty years ago, when the cost of sugar was more than double. In the light of modern physiological and pathological research, it seems conclusive that the dangers from an excessive use of sugar differ but little from those attending an excessive use of proteids or fats, and that sugar is as essential to a well-balanced ration as any other class of nutrients. In the production of heat and energy the proteid or nitrogenous foods and sugar are of about equal value, and it is claimed by some experts that the nitrogen retention from proteid foods is increased at least 25 per cent if consumed with sugar. The horror of succumbing to kidney or liver diseases if sweets are indulged in is passing, as a result of which many, and perhaps all, are indulging in those sweets more freely. In the wisdom of moderation an excess is to be avoided, since it must result in indigestion, which in its various forms is the mother of most of the ills of humanity.

SUGAR CANE ERA.

Cane was without a successful rival in the production of commercial sugar until the middle of the nineteenth century, when Germany and France began a vigorous and persistent development of the beet sugar industry. Limited quantities of maple sugar were manufactured in America and Europe and date sugar was a popular sweet in China, but neither had an appreciable effect on the sugar market. That the beet sugar industry as late as 1836 was still in its experimental stage is evidenced by the fact that, in that year, the total production in France and Germany was less than 3,000 tons. England imported in this year 200,000 tons of cane sugar from the West Indies and 10,000 tons from the East Indies, which represented about one-half of the total world production.

In the seventeenth and eighteenth centuries the Dutch East Indies (Java, etc.), Spanish West Indies (Cuba, Porto Rico, etc.), British West Indies (Barbadoes, Hayti, etc.), Canary and Madeira Islands (under Spanish and Portuguese), and Brazil (under the Dutch) became the great cane growing regions for the European and American sugar supply.

The cane growing countries, in the order of production in 1908, are: British India, 2,046,000 tons; Java, 1,156,000 tons; Cuba, 961,958 tons; Hawaiian Islands, 465,288 tons; United States, 50,000 tons; Porto Rico, 200,000 tons; Queensland, 188,000 tons; Brazil, 180,000 tons; Mauritius, 170,000 tons; Philippines, 135,000 tons, and all other countries, 1,000,000 tons.

On the basis of value, 93 per cent of the sugar imported into the United States is cane sugar. The total cane sugar imports last year were valued at \$125,800,000, distributed as follows: Cuba, \$58,000,000; Hawaiian Islands, \$40,000,000; Porto Rico, \$19,000,000; Dutch East Indies, \$11,000,000, and the Philippine Islands, \$699,000. This means that, excepting British India and China, where the crop is consumed locally, the United States consumes 60 per cent of the world's cane sugar crop.

THE FUTURE OF CANE.

In the light of present development the future of the cane sugar industry is somewhat problematical. The beet sugar industry is increasing more rapidly than the rate of consumption, and the competitive conditions in the cane growing countries are becoming more difficult each year. Twenty years ago cane sugar constituted two-thirds (66.2 per cent) of the total world supply, while now it constitutes one-half; and yet in that period the total production was doubled. The cost of producing raw sugar is increasing in the leading cane growing countries, and the cost of producing beet sugar is diminishing through improvements in seed selection, cultivation, and machinery. It costs more than 2 cents to produce a pound of cane sugar in Cuba, and a little less than 2 cents to produce a pound of beet sugar in Germany. But Austria and Holland are making beet sugar at even a less cost than Germany. The cost of production in the United States is from 2½ cents to 3 cents per pound, which would indicate that the survival of the domestic industry has a vital dependence on the equalizing effect of import duties.

The present cane production in the United States is

about equivalent to the annual average during the past 15 years, which is convincing evidence that but little pressure would be required to bring about a decline in the cane sugar industry in this country. Not only is the cost of labor increasing in the Gulf States, but the profits from trucking, fruit growing, cotton and rice are increasing with the urgency of the demand.

THE RISE OF THE SUGAR BEET.

The economic production of sugar from sugar beets has solved successfully the problem of meeting the growing demand for this popular and valuable food. The nations of the temperate zone are the great sugar consumers of the earth, and the sugar beet is strictly a temperate zone plant. Like many other profitable industries, it developed slowly in its early stages, but is now progressing at a rate which is truly alarming to the countries whose chief source of revenue has been the cane sugar industry. The phenomenal increase in production is due to the growing demand for sugar, the profits realized by the grower and the manufacturer, the wide climatic and soil adaptation of the crop, and the steady increase in the amount of sugar contained in the beet. In 1885, the beet crop of France had 7.83 per cent sugar, and the German crop averaged 12 per cent; as compared with 12.6 per cent in France, and 17.5 per cent in Germany in 1908. With this record it is not surprising to find that Germany increased her beet acreage from 600,000 acres in 1885 to more than 1,000,000 acres in 1908; and her sugar output from 850,000 tons in 1885 to 2,223,000 tons in 1908.

IMPORTANT BEET GROWING COUNTRIES.

Beets have been successfully grown for the manufacture of sugar in all of the continental countries of Europe, and in the United States and Canada. The latitude zone may be said to extend from 45 deg. to 58 deg., according to the general climatic conditions. Most of the beet producing countries have a mean annual temperature of 55 deg. to 65 deg. F. The Department of Agriculture has defined the economic beet zone for the United States, as a belt 100 miles in width on either side of the June, July, and August isothermal line of 70 deg. F. The moisture supply is of paramount importance with temperature; and since it is almost impossible to obtain a distribution of rainfall ideally adapted to the crop, the most satisfactory results are realized under irrigation.

Europe had last year 4,860,000 acres in beets, which produced 7,041,000 tons (2,204 pounds) of sugar. Of this enormous sugar crop Germany had 2,223,521 tons, more than one million tons of which were exported. The largest producing provinces in Germany are Saxony, Brandenburg, East Prussia, and West Prussia. Saxony has long taken the lead, with Magdeburg as the great manufacturing and refining center, but the present tendency is toward the shifting of the center to Prussia.

Austria-Hungary is the second largest beet grower, with 816,000 acres and a sugar production of 1,409,000 tons. There are 119 sugar factories in Bohemia, 61 in Moravia and Silesia, and 24 in Hungary. Sixty per cent of the total crop is exported to the various sugar importing countries of Europe.

Russia ranks first in acreage (1,386,996), and third in production (1,403,300 tons). These figures are a sufficient commentary on the inferior methods of cultivation in vogue. Russia has a continental climate which subjects the beet crop to great risks, but no other country possesses so large an area on which beets of average sugar content can be matured. The domestic industry has had the effect of increasing the domestic consumption. In 1850 the consumption in Russia was about one-half pound per head, as compared with 17.6 pounds in 1908.

France, the most enthusiastic of European nations in the early development of the industry, is not keeping pace with the other important beet growing countries. Her production in 1908 was 719,900 tons, manufactured by 255 factories. The French have made less progress than the Germans and the Austrians in the development of beets of high sugar content, the average in France being 12.6 per cent, in Austria 17.2, and in Germany 17.5.

Proportionate to area Belgium is the largest beet sugar producer in the world, one hundred and forty thousand acres producing 231,000 tons. On account of the size of the country and density of the population it is impossible to appropriate a much larger acreage to beets.

Holland cultivated 120,000 acres, giving a production of 173,000 tons. The crop is manufactured by 28 plants, many of which are also engaged in refining the

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raw sugar imported. The cost of production in Holland is about 1.5 cents per pound, which is lower than in any other beet growing country. The retail price is 9.4 cents per pound (Amsterdam), the result of the high consumption tax of 4.6 cents per pound.

Italy is the next largest producer in Europe, having an output in 1908 of 150,223 tons. Although limited areas are adapted to the cultivation the Italian production is being steadily increased. Here the consumption tax is highest, 5.7 cents per pound, and the retail price highest, 13½ cents (Naples and Milan). The poverty of the masses, and the high price make a small consumption imperative, 8.3 pounds per head.

Sweden has expanded the industry to 109,500 tons, which so nearly satisfies the domestic demand that the total sugar and molasses import in 1908 was only \$16,654. The cultivation of the beet is concentrated in Scania, with manufacturing centers at Helsingford and Kzeffinge.

There is a limited production in Spain, Denmark, Roumania, Switzerland, Bulgaria, Greece, and Servia.

STATUS IN THE UNITED STATES.

The first permanent beet sugar factory in the United States was constructed in 1870 at Alvarado, Cal., 32 years after the government made its first favorable report on the possibilities of the industry. Unfortunately the first experiments were conducted in the humid States of the East, which produced beets low in sugar. The development was slow but steady following 1870. In 1892, we had only six factories in operation and a

total production of 13,000 tons of sugar. With the passage of the Dingley Bill of 1897 the industry was inspired with a new life, resulting in the construction of fourteen new factories in 1899. The growth of the industry since 1897 is a record unparalleled by any other beet growing country, having increased from 40,000 tons (1897) to 420,000 tons (1908). From 1890-1908 the cane sugar production in the United States increased scarcely 10 per cent, while the beet sugar production increased from 2,223 tons to 420,000 tons. The acreage has been more than doubled since 1901, and the production has been more than doubled since 1904. Sixty-five factories are in operation in sixteen States, Colorado and Michigan leading, each with sixteen. The important beet growing States in the order of production are: Colorado, California, Michigan, Utah, Idaho, Wisconsin, Kansas, Montana, New York, and Minnesota. California, Michigan, Wisconsin, and Idaho lead in crops of highest average sugar content.

The total beet and cane sugar production in the United States supplies but one-fifth of the domestic consumption. On the estimate that our laboring constituents receive an average of 3 cents per pound in the production of home-grown sugar, \$167,000,000 would be added to the pay-roll, if the production were equal to the consumption. Can we anticipate such a development with hope? Why not? The Department of Agriculture estimates that the United States has 274,000,000 acres adapted by soil and climate to the cultivation of beets, and that if this area were culti-

vated in four rotation crops, beets constituting one, the annual sugar production would be 15,000,000 tons. The domestic demand would be supplied by the cultivation of 1,500,000 acres, if the crop only averaged eight tons per acre. The average price paid for beets in 1908 was \$5.35 per ton, as compared with \$4.10 in 1897. The profits have been so satisfactory in the irrigated regions of the West that the price of land adapted to beets has increased since 1905 from 20 to 60 per cent more than the same grade farms not adapted to beets. The factories have also flourished, as evidenced by the construction of more than fifty from 1900 to date. The total capital invested is conservatively estimated at \$70,000,000.

FLUCTUATION IN CONSUMPTION.

The amount of sugar consumed varies with the financial situation and the price of the commodity. From 1890 to 1900 the country experienced a general financial depression, as a result of which sugar became a luxury to the poorer classes. During this period the consumption increased from 51 pounds per head to 58.8 pounds, an increase of 15 per cent. From 1900 to 1907 is recognized as a period of unprecedented business prosperity, and the sugar consumption increased from 58.8 pounds to 82.6 pounds, an increase of 40 per cent. In the interpretation of these statistics it should be remembered that from 1890 to 1900 the average price of refined sugar on the New York market was less than the average price from 1900 to 1907.

A FORERUNNER OF COPERNICUS.

FORGOTTEN NICOLE ORESME.

BY PROF PIERRE DURHAM.

In the year 1368 Albert von Helmstaedt, better known by the name of Albert de Saxe, a celebrated master of the Faculty of Arts of the University of Paris, wrote a commentary on Aristotle's Treatise on the Heavens and the Earth. One of the questions propounded in this treatise is "whether the earth, placed in the center of the universe, is continually at rest or continually in motion." In regard to this question Albert asserts that "one of my masters appears to profess" that it is impossible to demonstrate that the movement of the earth and the immobility of the heavens are incompatible with the observed phenomena. Albert then proceeds, with all respect to his master, to demonstrate this incompatibility by the orthodox methods of the schoolmen. The interesting point in all this is the evidence furnished of the existence, in the middle of the fourteenth century, of a professor of the University of Paris who regarded the rotation of the earth even as a possibility.

Although this unnamed and unknown master did not convince Albert de Saxe, he appears to have had better success with another student who attended lectures at the university about the same time. This student was Nicole Oresme, of Bayeux, who came to Paris in 1348, to study theology, and in 1356 became grand master of the College of Navarre. In 1362, after having obtained the degree of master in theology he was appointed a canon of Rouen, and two years later he was promoted to the rank of dean of the chapter. He was created bishop of Lisieux in 1377 and died in that city in 1382.

Oresme was endowed with remarkable mental activity, and wrote a great number of works, some in Latin and others in French, in a style that made him one of the acknowledged masters of that language in the fourteenth century. His treatise on money and coinage, written both in Latin and in French, exhibits him as a pioneer in the science of political economy, and Curtze has shown that Oresme, in a brief mathematical tract, forestalled Descartes and Ferneat in the invention of geometrical coordinates.

The reigning king of France, Charles V, was desirous of disseminating among his subjects the knowledge that had been restricted to scholars acquainted with Latin. In pursuance of this design the king appealed to the dean of Rouen, to whom he had already given many tokens of his confidence and esteem.

Oresme had already written in French a "Treatise on the Sphere, designed to teach the form and arrangement of the world, the number and order of the elements and the movements of the heavenly bodies, to every man of free condition and noble mind." The king now commissioned him to write French translations and commentaries on some of Aristotle's works. In 1370-1 Oresme translated Aristotle's Ethics, Politics and Economics. These translations and commentaries were printed in the 16th century. Oresme also wrote a translation, with extensive commentaries, of Aristotle's Treatise on the Heavens and the Earth. This

work has never been printed; but several manuscript copies are in existence. One, in the possession of the Bibliothèque Nationale, is adorned with miniatures and bears the signature of the Duc de Berry, brother of Charles V.

In the second book of the Treatise on the Heavens and the Earth Aristotle proves, to his own satisfaction, that the earth remains motionless in the center of the universe. After translating this section Oresme proceeds to give his own opinion, "subject to correction," that the earth revolves daily on its axis and that the heavens are motionless. He develops this opinion at great length and clearly and ingeniously shows the fallacy of the arguments urged against it—for example, that the rotation of the earth would not account for the rising and setting of the sun, moon, and stars, that it would necessarily produce a mighty east wind (the air being assumed to be left behind), and that a stone thrown vertically upward would strike the ground to the west of its point of departure. Oresme takes the example of a ship moving very steadily eastward and shows that, to an observer on board that ship, a motionless vessel would appear to be moving westward, and that it would be impossible for such an observer to decide which of the two vessels was moving. He explains that the atmosphere moves with the earth as air confined in a closed vessel moves with the vessel, and that a stone thrown vertically upward also moves with the earth, both in ascending and in descending, so that it necessarily returns to the point from which it was thrown. Hence he concludes that it is impossible to prove by experiment that the heavens move and the earth remains at rest.

After having thus shown the futility and fallacy of the appeal to experience, Oresme proceeds to refute the religious, metaphysical, and astronomical arguments in favor of the immobility of the earth. Here it becomes uninteresting and tedious to follow him. The same remark applies to his support of his own opinion by positive arguments, of which some are sound and ingenious and others metaphysical and absurd. One argument is rather amusing. Oresme says that if one thing receives benefit from another it should obtain this benefit by its own movement. Hence the earth, in order to receive the heat and light of the sun in all its parts, must rotate on its axis, instead of requiring the sun to revolve around it. Thus the roasting joint turns on the spit before the fire, but the fire does not move around the spit.

Did Copernicus possess any knowledge of this dissertation in favor of the daily rotation of the earth? It appears impossible to give a decisive answer to this question. Master Nicole Oresme's commentary on Aristotle's work, written in French, at the king's command and cost, by one of the most important members of the University of Paris, should have had a great vogue in France, but the fact that it was written in French probably prevented its becoming widely known among foreign scholars. It is a very remark-

able fact that this one work has never been printed, although the Treatise on the Sphere, which was often appended to it in the manuscripts, in accordance with the author's expressed desire, was printed in the sixteenth century. Hence it is very possible that Copernicus was ignorant of the existence of Oresme's work.

On the other hand, the arguments advanced by Copernicus, in his treatise *De Revolutionibus Orbium Coelestium*, in support of the possibility and probability of the daily rotation of the earth, so strongly resemble Oresme's reasoning, that this part of the great work of Copernicus might well be taken for a concise and somewhat obscure *résumé* of the corresponding portion of Oresme's commentary on Aristotle's Treatise on the Heavens and the Earth.

At all events, it is certain that the work of Nicholas Copernicus was anticipated, even if it was not inspired, by that of Nicholas Oresme.—Translated for SCIENTIFIC AMERICAN SUPPLEMENT from *Revue des Sciences Pures et Appliquées*.

AN AFRICAN ELEPHANT FARM.

ONE of the great obstacles to agricultural development in the equatorial districts of Africa is the difficulty of procuring beasts of burden. Horses have been tried in vain; oxen soon become useless; the ass would no doubt be a serviceable animal, but it is difficult to acclimatize; while zebras, in spite of many attempts that have been made to break them in, have never been domesticated to any serious extent. In these circumstances some interest may be felt in an experiment which is being carried on by Commandant Laplume at Api, in the Congo Free State, and of which some particulars are given by M. Daniel Bellet in *Cosmos*. The African elephant has been generally considered as quite intractable; but Commandant Laplume is of opinion that much may be done with him if caught young. The catching takes place during the dry season. A party is made up, who set out to look for the fresh spoor of elephants. They only follow those tracks which indicate that the herd contains calves of the right age to undergo training. As soon as the herd is sighted, guns are fired to frighten the animals and send the old ones flying. The calf also runs or tries to run, but its slowness permits the hunters to catch it up. A rope is passed round its neck, a second round its body behind the fore legs, and then a third attached to the two others. Three or four men walk in front, holding one end of the last rope, while the other end is held behind in the same way. It is necessary to take the greatest care to prevent the animal being injured by the ropes in any way, as even slight wounds are very dangerous to the calves, and they are brought in to the farm as tenderly as possible. The task of catching has been materially lightened of late, because several of the elephants, captured in former years, have been trained to assist the hunters.

In spite of all precautions, however, the losses are