THE EVAPORATION OF WATER BY PLANTS.

In order to measure with precision the quantity of water necessary to maintain a plant constantly in a proper condition of moisture, it is necessary to determine the enormous amounts of liquid which the vegetable evaporates. The method of obtaining such result is quite imperfect, for since metallic plates are arranged over the plant and pot so as to cover completely the earth, and it is impossible to hinder an evaporation from the surface of the soil, it is manifestly difficult to affirm that all the fluid employed in the watering has traversed the plant.

M. Deherain communicates to *La Nature*, to which journal we are indebted for our illustrations, records of his investigations in the subject, which have extended over several years. In order to collect the water evaporated, he fixes a leaf of the plant in an ordinary test tube by means of a split cork. The tube is held by a support so as to retain the leaf in its normal position (Fig. 1). When the apparatus thus arranged is placed in the sun, dew quickly appears on the interior of the cylinder, and augments rapidly until, at the end of an hour, a quantity of water may be collected, often equal to, and sometimes of twice the weight of, the leaf. In several examples given by the author, we note that of a leaf of wheat, weighing 36·1 grains, yielding, in the above period, 30·1 grains of water, equal to 88·2 per cent of the weight of the leaf. A more striking instance is that of corn leaves gathered after a prolonged drought, giving 229, 187, 179, and 178 per cent of their weight in water, the largest proportions yet determined.

In order to obtain from the leaves such excessive quantities of fluid, it is necessary to expose them to the sun for a time: for if they be submitted merely to diffuse light, evaporation diminishes perceptibly, while it ceases almost entirely in darkness. A wheat leaf exposed to the sun gave, as above noted, 88·2 per cent of its weight of water; in diffuse light this proportion was reduced to 17·7 per cent, and in darkness to 1·1 per cent. These experiments are very simple and easy, and any one interested in the subject can repeat them for himself with little trouble.

It appears difficult, from the above results, to avoid the admission that light has a decisive influence on the phenomenon. In order, however, to render certain the fact that the abundant transpiration in the tube was not due to a warming of the confined air by the sun's rays, during the entire experiment the leaves were kept at a low temperature, either by placing the tube within another, through which passed a current of water (Fig. 2), or surrounding the inner cylinder with crushed ice, which was constantly renewed. Thus arranged, a wheat leaf, weighing 2·7 grains, gave 2·5 grains of water in the sun and only ·045 grain in darkness. The liquid between the tubes was kept at 59° Fah. At a temperature of 39·2°, gained by the aid of ice, in an hour in the sun, the leaves gave off 108 per cent of water.

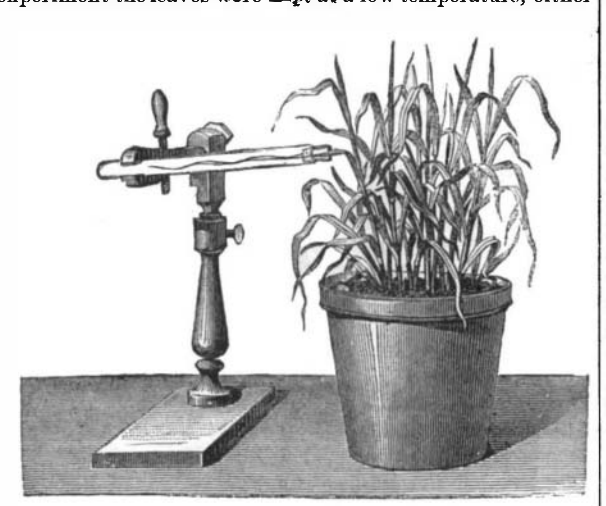

FIG. 1.—Apparatus showing the quantity of water evaporated by leaves.

It is, then, the luminous heat which determines the evaporation as well as the decomposition of carbonic acid by the leaves; and it is curious to note whether, in pursuing the comparison, we should eventually recognize that the luminous rays, potent in determining the decomposition of the carbonic acid, are equally efficacious in favoring evaporation. In causing the first mentioned effect, the brightest rays, red and yellow, are known to be the most active. This fact may be determined by placing a marsh plant in a weak solution of carbonic acid and then surrounding the vessel with a cylinder containing various colored liquids. It will be found that the green and blue rays, which blacken photographic paper so rapidly, act but feebly, and cause but a very light disengagement of oxygen, while, on the other hand, the red and yellow rays, inoperative on sensitized paper, are singularly energetic in causing the decomposition of carbonic acid. Now, precisely these same rays favor the evaporation of water by leaves, and this is experimentally demonstrated in the apparatus represented in Fig. 3. The tube holding the leaf is placed in a glass, which is filled with a colored solution arranged so as to be easily drawn off and replaced, when necessary, by other liquids. The leaf is then caused to be illuminated by variously tinted lights, and it is found that the efficacy of the rays in determining evaporation ranges in the following order: yellows, reds, blues, and greens. When the outside vessel contains a yellow solution, a quantity of water double that given off by the leaf when submitted to a green light is collected.

Analogous results are obtained by using the solar spectrum obtained through a glass prism. The light (Fig. 4) is reflected by a heliostat to the prism, undergoing separation, and the tubes are arranged in various parts of the refracted rays. The facts already recorded are plainly discernible.

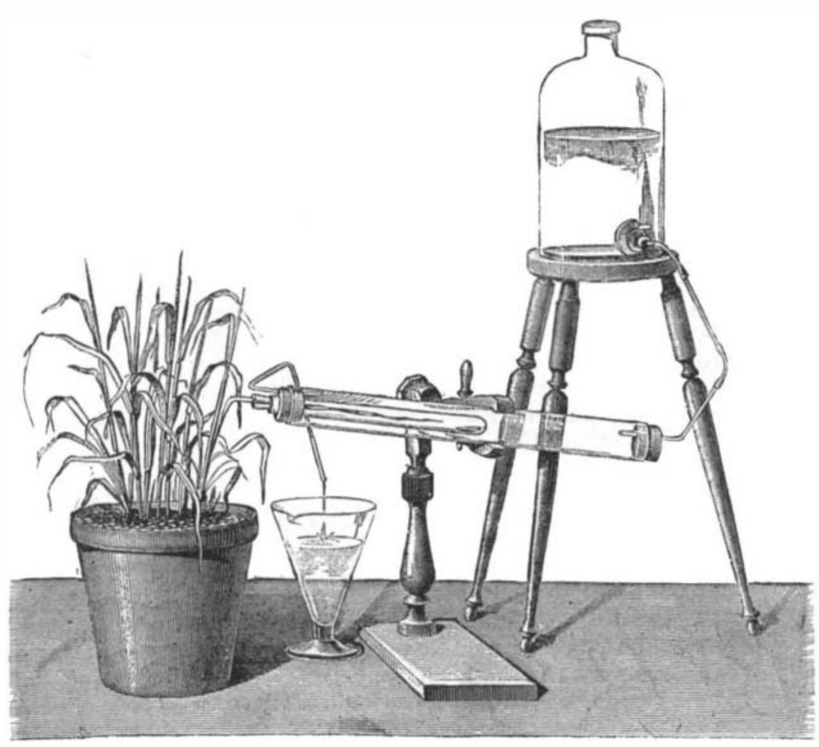

FIG. 2.—APPARATUS SHOWING THAT THE EVAPORATION IS DUE TO LIGHT.

It may be considered, as determined from the preceding, that the rays efficacious in causing the decomposition of carbonic acid are also those which favor the evaporation of water by leaves, and thus two very important phenomena of vegetable life appear to be connected by a bond, the nature of which is still unknown.

By determining the evaporation of a cultivated surface, we may be able to draw important conclusions on the quantity of water which it should receive in order that the growing plants thereon may prosper. It has been found that in a thinly planted field of corn, where thirty stalks were counted per 10·7 square feet, the weight of the leaves was about 3,732·6 grains. These leaves on a clear day gave off at least 150 per cent of water per hour, or in ten hours 1,500 per cent. The 3,732·6 grains of weight of the latter should therefore give off 55,902 grains of water, or something over one gallon. If, therefore, 10·7 square feet (square meter) yield a quantity equal to some 6·6 pounds, 2·4 acres (hectare) will give about 33 tuns. This is not far from the conclusion reached by Hales, a celebrated English naturalist, nearly a century ago, as he estimated that 20 acres planted with cabbages evaporated 706 cubic feet of water per day, while more extended investigations by Schleiden, the botanist, on fields of grass and clover, gave 21 tuns per similar area.

These figures, however, relate to ordinary and general agriculture, fields, etc.; but if we consider the cultivation of vegetables for the market—kitchen garden culture—we should find, corresponding to the quantities of irrigating water, results infinitely more elevated. It is estimated that the kitchen gardeners of Paris throw, per year, upon the rich soil, water equal to a depth of 12·8 feet. Considering that cultivation continues for 250 days per year, for in winter it almost entirely ceases, it is found that every 2·4 acres receives daily 5,648 cubic feet of water. The result is that, thus treated, the earth yields crude products to the value of from four to six hundred dollars per 2·4 acres instead of from one to one hundred and fifty dollars, as would be the case in extended agriculture.

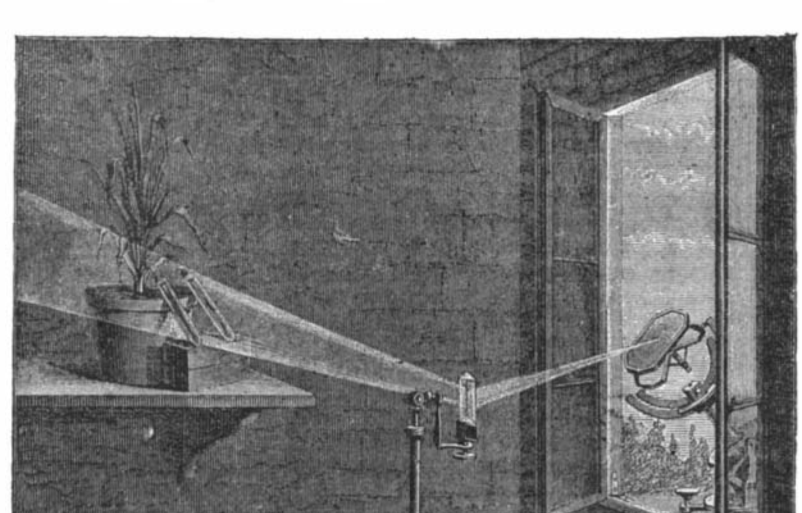

FIG. 4.—APPARATUS FOR DISTINGUISHING THE EFFECTS OF THE RAYS OF THE SOLAR SPECTRUM.

Floors of Mortar in Mexico.

General T. G. Ellis describes, from personal observation, the following method used in Mexico:

"The limestone used was a hard, compact, blue material, in some places sufficiently hard to strike fire on the drills used in running a drift through it for mining purposes. It often contains iron pyrites in small proportion. This was calcined in kilns cut out of a very soft limestone, that likewise is found in that section of country, and which, on account of its whiteness and softness, is called *cal leche*.

After calcination the lime was removed from the kilns, and slaked as soon as cool. Some of it was used within a day or two, and some remained a month or more in barrels. All the work made with it seemed to be equally good.

In making the floors, a layer of broken limestone, three or four inches thick, was first laid evenly over the surface of the ground, the stone being about the usual size for macadamizing roads. Over this a mortar of about two parts of sand to one of lime was carefully and evenly spread to the thickness of 1½ or 2 inches; this was allowed to remain for about twenty-four hours, or until the surface had become quite dry. It would probably take longer in this climate, where the air possesses a greater amount of moisture than in Mexico.

The floor was then thoroughly pounded all over with a tool composed of a block of wood about 1 foot square and 3 inches thick, having a handle rising from the middle, so that a man could stand while using it. The whole surface was beaten down with this ram until it was again as soft and moist as when first laid. This operation of ramming brought the water in the mortar to the surface so as to form a layer of semi-fluid substance on top.

The floor was again allowed to dry, and again beaten over each day for about a week, when the operation brought only a slight amount of moisture to the surface.

Immediately after the last pounding the whole surface was powdered with a thin layer of red ocher, evenly sifted on, and then polished as follows:

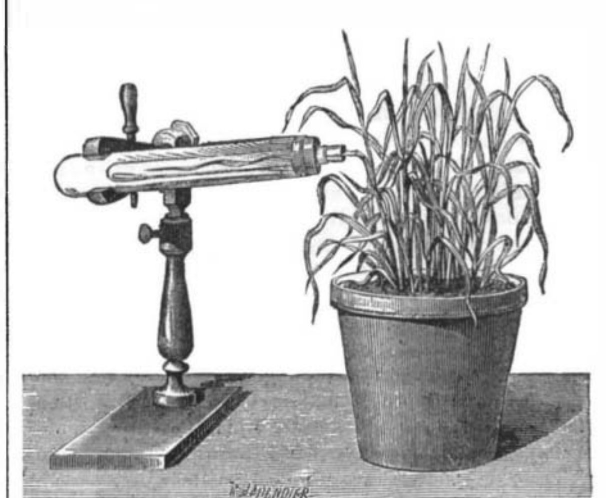

FIG. 3.—Apparatus for distinguishing the effects of variously colored rays.

A smooth, nearly flat, water-worn stone, a little larger than the fist, was selected from the bed of the stream which ran through the place, and with this the whole floor was laboriously gone over, rubbing down, and leaving the surface of the lime as smooth as a piece of polished stone, the red of the ocher rendering it of a rich brown color.

In less than a week the floors made in this way were sufficiently hard to bear the weight of a horse without indentation. Roofs were made in the same manner, without the coloring matter, which was added only to give the floors a better tint than the gray of the mortar. These roofs were perfectly waterproof, and were unaffected by sun or rain.

In the city of Monterey, sidewalks in the principal streets are made in the same manner, and some of them have lasted for years, wearing through like a block of stone.

The great durability and strength of these floors and roofs are entirely owing to the pounding operation above described, as the same materials were tried in the ordinary way without success.

The writer has not had occasion to make use of this process in this climate, but gives a description, hoping that it may be of value to others who may have occasion to lay floors of lime in architectural or engineering works. He has never heard of this method being employed in this country; although it seems singular that it should be used so generally by a neighboring nation, and be wholly unknown to our builders."

Our readers will perceive that this method of using mortar is analagous to the French mixture known as Coignet's *béton*, which, when thoroughly rammed as above described, forms artificial stone of great strength impervious to water. M. Coignet appears to have been long anticipated by the Mexican builders.

Correspondence.

The Manifestation of Energy in Nature.

To the Editor of the Scientific American:

If we would ignore the assumed existence of the hypothetic ether, and look upon every particle of matter as being the center of a ubiquitous sphere of static energy or influence, natural phenomena could receive a better explanation. From our knowledge of matter we say that it is indestructible; and as every portion manifestly influences in its motion every other, we may say that its energy is practically ubiquitous, and continually exercised for the attainment and maintenance of equilibrium. Faraday supposed the existence of "physical lines of force;" and both Thomson and Maxwell show that this hypothesis gives a more correct view of electro-magnetic action than the usual mathematical expression. As then all that we know of Nature is summed up in matter and energy, we may fairly assume the physical existence of both, while looking upon the essential nature of either as beyond the reach of speculation. By this means we rid ourselves of unwarrantable hypotheses. Space becomes neither a vacuum nor filled with one or more impossible ethers. Electric or magnetic phenomena are not action at a distance, but action along unbroken lines of induced force within a body's sphere of energy, the transversal vibrations of such lines when broken into an advancing wave constituting heat and light.

The constitution of every cosmic system proves the physical existence of energy. Static potency is inversely as the distance from the center of exerted power, as shown by the lever or balance. The centripetal force varies inversely as the square of the distance, the centrifugal as the cube. This makes the revolving force to vary inversely as the distance, when both tendencies are produced from the same center, as in the common illustration of a sling—constraint and outward motion acting along the same connecting line. But the physical connecting line is necessary. Now we find, in every cosmic system, the energy of motion (velocity squared) of every revolving body to be inversely as its distance from the united balancing center.

The solar system, say, represents a certain amount of energy—that of the matter composing it—and is formed in the universal tendency to equilibration, by the matter blending its energies into one common concentric sphere for the mutual balance of the various bodies. The laws of Kepler, in regard to which there has been so much speculation, become inevitable. Equal areas are moved over by each body in equal times. As the force of motion is inversely as the length of radii in the concentric spheres encircled in revolution, the linear length defines the time occupied in motion by each body. The radii squared give the respective areas swept over in revolution. The areas (radii, or times squared) therefore, described by the different bodies, must be to each other as the volumes of energy in the concentric spheres of which they are great circles. The squares of the radii for areas are to each other as the cubes of the same for the volume of energy, which gives the areas to be moved over.

The blending of energies into one common center of balance explains the law of gravitation. For matter must approach until stable equilibrium is attained by the proportional masses, at the necessary distance from the united center of gravity. But by the principle of the conservation of energy, when the bodies have attained balancing distance in free space, the force of approach necessarily becomes transformed into revolutionary motion. Of this deviating force, the Newtonian law renders no account. But the ascription of physical energy to matter, with its universal tendency to equilibrium, not only explains but shows the necessity of the conservation of both centripetal and tangential tendencies.

The theorems of La Grange and La Place are necessitated also by the physical reality. For that definite amount of energy which centered itself for the equilibrated motion of bodies cannot otherwise than conserve what it formed, local action being continuously neutralized by counter strain.

My conclusion, then, is, that matter and energy are physical realities, because they constitute all that we know of Nature. The energy of every particle of matter we look upon as universal because it acts upon all others. The energy of every body is exercised in maintaining or in striving to attain equilibrium with all others, and may act either attractively or repulsively, according to the most powerful enforcement or solicitation; we find that Nature teaches this also. To this variation of action, according to molecular constitution, must be ascribed cometary eccentricities. In apparent defiance to the gravitating law, cases of division and permanent separation of parts have been witnessed. Static potency is inversely as the distance from the center of balance; as we see that a small body will, by a nearer approach to the center of the earth, raise a much larger, if only at a greater distance from the balancing center, although both originally were at the same distance from the earth's center, and the larger body attracting according to its mass. Radiant action, or vibration from the center of a body's sphere of energy, outwards, must vary with the square of the distance, and also tractive potency if acting in all directions. Such variations of potentiality bring about all natural charges amidst all tendencies to equilibrium; and the amount of energy in the universe is measured by its matter. The energy of the atom is no less universal than indestructible.

Philadelphia, Pa. WM. DENOVAN.

The Million Dollar Telescope.

To the Editor of the Scientific American:

Much has been said about this proposed instrument, and several plans given. I have another plan that, if it be not too visionary, will be far less expensive than and fully equal in its results to any other. I have read somewhere, or else I dreamed it, that if a plate of glass be placed over a circular opening and the air exhausted from behind it, the glass is bent back by the pressure of the atmosphere, and it may be made to retain this concavo-convex form. If this be true, why may not the lens be made in this way and filled with bisulphide of carbon? I see no reason why it may not, for all the glasses needed may be made of any convexity required Some genius can certainly work this out.

It has been proposed that the telescope be erected at Philadelphia, and that, during the exhibition of 1876, people be allowed to look through it at so much per head. This might do to raise money, and many would take the look just for the name of it, though very few would appreciate the sight. It requires a knowledge of such things and a taste for them to appreciate them properly. I have shown persons objects of the lesser world through the microscope; and though they considered themselves cultivated, they no more appreciated those beauties than would Lo, the poor Indian. There are many people, too, who are very fond of pictures; but after all, they do not appreciate them: they lack the knowledge of and taste for art. One may admire, and yet not appreciate. Thus it would be with the great telescope. While many might, from curiosity, want to gaze at the stars, the instrument would be doing mean service. Far better that it be placed at some point favorable for observation, and some experienced observer appointed to use it, and then we may expect it to do something worthy of so great an instrument.

I would willingly forego a look through it, much as I might desire it, that it might be used to better purpose. It is just the thing that I have thought of for years; if I were worth the million, I would have constructed it at my own expense for the benefit of science; but as I am worth less, I will have to stand back and wait awhile. Still, I hope the project will be carried out in some form.

Sans Souci, Ohio. X. PERRY MENTOR.

[Special Correspondence of the Scientific American.]

UP THE AMAZONS.

NO. 1.

PARA.—ITS SITUATION, CLIMATE, INDUSTRY, AND COMMERCE.

The largest city on the largest river in the world, and the sole commercial outlet of a region equal to the United States east of the Mississippi but really more fertile: such is Pará.

It is a city of strange contrasts. Founded two hundred and fifty years ago and having an unparalleled position, it has to-day but thirty-five thousand inhabitants, a slow growth, due mainly to revolutions, yellow fever, and absurd legislation. Standing seventy miles from the ocean, it is nevertheless approachable by the largest steamers. It is built on a low tract of land, so that at a distance it appears, like Venice, seated on the sea, with beautiful rocinhas nestling in gardens along the shore, and every variety of craft, from frigate to canoe, on the water; hemmed in between the river Guajará and a perpetual forest that stubbornly disputes every inch of ground; with picturesque avenues of mongubas, graceful palms, and superb bananas in elegant luxuriance: with unpaved streets, neglected plazas, dilapidated houses, sombre churches with grass and shrubs growing on their tiled roofs; with screaming parrots and toothsome vultures, yellow dogs and chattering monkeys; with wealthy Brazilians in spotless white, noisy Portuguese porters, idle soldiers, merry negresses with trays or water jars on their heads, sober Indian women with naked children astride on their hips or rolling in the street; with a mongrel population of amalgamated Portuguese, Indian, and Negro blood—mulattos, Ma-melucos, Cafuzos, Curibocos, and Xibaros; everywhere the signs of human indolence and Nature's thrift, of filth and poverty alongside of overpowering beauty and wealth of vegetation, yet altogether leaving a pleasing impression on the mind which can never fade.

Pará (officially called *Belém*—the Portuguese for Bethlehem), is justly celebrated for the almost perfect equilibrium of its climate. The temperature ranges from 73° to 93°, the mean of the year being 81°. The heat is never so oppressive as in New York, being tempered by strong sea breezes and afternoon showers. Were it not for the imported diseases, Pará would be the paradise of invalids. In 1819 the small pox first visited the city, in 1850 came the yellow fever; and in 1855, cholera. The natives suffer most from the first epidemic, and foreigners from the second. At the present time (July), the small pox is at work, not only in Pará, but also in Manáos, a thousand miles up the river. As

AGRICULTURE

is at a low ebb and import duties high, living is dear in comparison with former rates or with what we might expect in a city on the edge of an empire of exhaustless fertility. Luxuries are exorbitant. Hotels charge $2.50, gold, per day. Enterprise runs mainly to small shopkeeping and wholesale trade in rubber and cacao. But there is progress toward a better state of things. We notice many changes since our visit in 1867. The passport system was abolished last year. The State religion is more tolerant (the Jews have a synagogue), and religious holidays, which once seriously interfered with trade and industry, have been reduced in number. Among the new public buildings are the President's Palace and the Grand Opera House. The latter will cost $500,000, and contain a theater accommodating 1,600 persons and a saloon holding 1,200, in every respect out of all proportion to the wealth and size of the city. There are two banks, with a joint capital of $6,000,000. The city is lighted by a London company, the gas costing four dollars per thousand cubic feet. A circular railway now connects Pará and Nazareth, and is well patronized by high and low. The rolling stock consists of five locomotives, fourteen passenger and eight freight cars.

There are very few Germans, French, English, and Americans in Pará; but of Portuguese there are about 5,000, all busily coining money as shopkeepers, artizans, carmen, boatmen, etc. The native Brazilians are exceedingly jealous of them. They complain that these foreigners are monopolizing the trade of the country; but instead of vigorously competing with them, they threaten to drive them back to Portugal. While agriculture, such as it is, is carried on by the Tupuyos or civilized Indians, the mechanical arts are mainly in the hands of the Portuguese. Among the

INDUSTRIAL ESTABLISHMENTS,

there are fifty-nine bakers, forty-three tailors, thirty-six shoemakers, thirty-two carpenters and joiners, twenty barbers (including such as bleed by lancet and leech), nineteen tinners and glaziers, sixteen blacksmiths, thirteen butchers, ten printers, eight sugar refiners, eight soap and tallow chandlers, eight makers of fireworks, four dentists, four bookbinders, four confectioners, three photographers, three saddlers, three tanners, and three potters. No foreigner can practice a profession (as medicine or law), and charge for his services, without a certificate from the University at Rio. Dentistry, being considered a mechanical art, is allowed. There are at present sixteen printing presses at Pará, from which issue fourteen journals—five dailies, three semi-weeklies, and six weeklies; four bookstores; one college (*Lycéo Paraense*) with twelve departments: a normal school, having a course of three years; a library, museum, and literary club.

The great want of the country is laborers of all kinds, but especially field hands. Agriculture has been ruined by the universal rush into "extractive industry," that is, the collection of the natural products, as rubber, nuts, sarsaparilla, etc. The rubber trade absorbs supreme attention; sugar cane is grown for the manufacture of rum, sugar being imported from the southern provinces; and the cultivation of cotton, rice, coffee, and cacao along the Amazons is nearly neglected. Another check to commercial enterprises is the high and irregular tariff. The duty on imports varies from five to eighty per cent. Ordinarily it may be reckoned at forty; but the same goods will enter at different rates, evidently depending on the caprice of the official. Bribery is openly practiced and expected. The duty on ready-made clothing is determined by weight, and on shoes, by the length of the sole. The usual cost of exportation is seventeen per cent; but the loss is much greater on certain products, as cabinet woods. This practically discourages labor by taxing it. Not $400 were collected at the custom house on all the woods exported from Pará in 1868-9. Brazil abounds with the most valuable timber in the world, but is prevented from competing with other nations by this system of self-strangulation. There are but two or three saw mills on the Amazons. A dozen boards of the common wood of the country (cedar or itauba) costs eighteen dollars at Manáos. Fine rubber costs about fourteen dollars an arroba (32 lbs.) up the river, and the loss is about forty-five per cent in getting it to Liverpool or New York, half of which is for freight and the other half for custom charges.

But Pará is destined to enjoy an enviable rank among the commercial centers of the world. She can never have a rival at the mouth of the Amazons, for she occupies the only available spot, the northern channel between Macapá and Chaves being scarcely fit for navigation. Standing at the gateway of a magnificent valley covered with the richest and largest forests on the earth and at the *embouchure* of a river which affords an unparalleled extent of water communication, touching every country on the continent except Chili and Patagonia, Pará must become the

LIVERPOOL OF THE TROPICS.

Her most prominent citizens are men of progress, and the dead weights on trade and labor will soon be removed.

At present the commerce of a country of such vast extent and resources is ridiculously insignificant. As most of the articles of consumption are imported, and many of those produced are exported, the foreign trade is greatly in excess of the internal.

In 1872 the value of exports to England=$2,766,761; to the United States=$2,371,138; to France=$466,788; to Portugal=$247,222; to Germany=$38,438; to Southern Brazil=$171,469.

The greater part of the rubber goes to England and the United States (about 2,500 tuns to each); cacao goes chiefly to France; Brazil nuts, copauba oil, and tonka beans to the United States; straw hats, sarsaparilla, and tobacco to Southern Brazil; piassaba and fish glue to England; cotton, sugar, rice, farina, hides and cachaca to Portugal. During last year there entered the port of Pará twenty-four steamers and forty-nine sailing vessels (tunnage 62,393) bearing the stars and stripes; thirty-five English steamers and eighteen sailing vessels (tunnage 41,937); thirty-nine steamers and ten sailing vessels (tunnage 41,845) of the Empire; Portuguese sailing craft, twenty three; French, nineteen; and from other nations sixteen. The total value of exports from Pará in 1871 was $6,710,561, of which $5,323,135 belong to rubber.

In my next I will treat of the navigation and commercial resources of the Amazons. JAMES ORTON.