MEMORIAL CHURCH, ST. PETERSBURG.

LAST year the Municipality of St. Petersburg invited designs for a new church which they proposed to build over the spot where the late Czar Alexander II. was mortally wounded. Twenty-eight designs were submitted in reply to this appeal at the beginning of the present year, and the four premiums which were promised have been conferred on four Russian competitors. The design on our first page was submitted by Mr. T. G. Jackson. The plan is a Greek cross, with a central dome measuring 42 feet diameter, and wagon vaults over the four arms, and with three eastern apses. The arrangements are adapted to the somewhat inflexible requirements of the Russo-Greek ritual, which differ in many respects from those of the other branches of the Eastern Church. The interior was designed to be lined with marble on the lower part of the walls, and mosaic above in the vaults and dome, and the details were modeled in the older and purer Byzantine style, which is, perhaps, less popular in Russia than either pure classic architecture or those peculiar modifications of Byzantine, of which examples may be seen in that part of Mr. Fergusson's "Handbook of Architecture" which relates to Russia.—*Building News*.

[Continued from SUPPLEMENT 344, page 5486.]

THE PANAMA CANAL.

By MANUEL EISSLER, M.E., of San Francisco, Cal.

II.

THE PANAMA RAILROAD.

OWING to the important role which this road is going to play in the building of the interoceanic canal, I will devote a few words to this enterprise, which, having been undertaken and carried out by North Americans, will be of so much more interest.

To many, especially Californians, this recital will bring forth remembrances of times when many among us came to these shores across Panama, in search of fame and fortune.

This railroad must be considered as the most useful in the world, because the same assures to the inhabitants of the western coast of the two Americas an easy communication with the Atlantic. The work of constructing the same did not commence seriously till 1850, and its success was only decided by a fortunate chance, by an event which saved the company at a moment, when, discouraged, the same was going to be abandoned. Ever since 1835, the American Bidle had explored the isthmus with a view of studying a passage for a railway. At that time, Panama was completely in the decline—only a straggling village of five thousand inhabitants, asleep in their indolence and idleness. Of all those magnificent works of art, dating back to the old Spaniards (las Antiguas), of those fine paved roads, blazing in the sun, whose rays are reflected on the glittering pebbles, which wound around the town, and of which the principal one led to Porto Bello, nothing was left, hardly some mule trails in the valley of the Chagres.

Biddle followed the trail of the natives as far as Cruces, and from there reached Panama. Being a man of sound judgment and of practical intelligence, he understood on first sight the facilities which this passage offered in comparison to the routes he had formerly studied. Without taking more correct surveys, he went to Bogota to negotiate for a contract which assured to him concessions of land from the Colombian government. He then returned to the United States to organize a company, but died soon after reaching home.

In 1843, the French mining engineer, Mr. N. Garella, was engaged, as before mentioned. He studied the double project, canal and railroad. The events of 1848 led to the dissolution of this society, of which Mr. Joly de Sabla was president.

But that very year, 1848, saw the production of an event in the historical pages of the United States which made the construction of the Isthmus railroad an absolute necessity, namely, the discovery of gold in California.

The war with Mexico had given us by the treaty of Guadalupe Hidalgo our magnificent California, and soon afterward two lines of steamers were established: one from New York and one from New Orleans to Chagres, the other from Panama to California and Oregon. At the same time enterprising men occupied themselves with the future railroad, but the work would have dragged along if the discovery of gold near Sutter's Mill had not brought to the isthmus a great multitude of miners, who were too much in haste to double Cape Horn.

Obliged to anchor in the offing of the Chagres, the vessels had to set sail at the least wind and to seek refuge in the Bay of Limon, bordered in many places by a shallow shore where they could not disembark. They had to await the good weather, return to the estuary of the Chagres, and land in the frail canoes of the natives, at the risk of capsizing on the bar; then came the sojourn, more or less prolonged, in the miserable huts of the port, exposed to the "Chagres fever," then an interminable journey in launches or canoes, against the current of the river, then again a long tramp through the forests.

This flock of passengers, this exodus, gave a vigorous impulse to the efforts of the society, and soon Messrs. Totten and Trautwine left New York with a number of workmen and material.

The operations were to have commenced at Gorgona, in the center of the Cordilleras, and were to descend on both sides toward the Pacific in one direction, and toward the Atlantic in the other.

They brought along two little steamers to be used on the Chagres River, but they were of no use to them, and they had to take to the bongos of the natives for means of transport on the river, but it proved too slow and expensive, and also were interfered constantly by the enormous transit which the passage of the gold seekers occasioned. This plan of building the road had therefore to be abandoned and the work was attacked on the Atlantic side.

This modified plan was put into execution in 1850. The hardest portion of the work in the swamps about the island of Manzanillo was inaugurated, and the workmen, after a hard day's work, had to return to the hull of a wrecked brigantine, and to the condemned steamer Telegraph.

Slowly more workmen commenced to arrive; from forty men, the force grew to one hundred. Gatun was reached toward the end of 1850, and the company was able to forward material and provisions to that point, and more men arrived to make the embankments, cuts, and lay rails.

But the astonishing news of California's riches continued to come, the fabulous stories of this immense wealth turned the heads of the laborers, and they abandoned their unhealthy trenches for the happy land of bountiful gold. The work of railroad building had to be abandoned.

Col. Totten and his worthy associates had to look for other workmen at Cartagena and the Antille Islands, and toward December they gathered about one thousand men together. In October, 1851, the provisory roadbed between Gatun and Colon was finished and the service established, and also a temporary dock constructed on the seashore at Colon.

Success was near at hand, but, unfortunately, the money had all been spent and the first million of dollars subscribed was gone. The value of the shares had fallen so low that a new subscription could not be counted upon.

By one of those providential circumstances, two steamers happened to come in at that critical moment into the port of Chagres, but could not disembark their passengers on account of a fearful hurricane. The next day was so stormy that the steamers could not hold to their anchorage, and had to take refuge in the Bay of Limon, near the island of Manzanillo, where they found calm waters. The emigrants there saw the gravel trains coming and going, and the idea struck them to mount them and gain in that manner Gatun, instead of waiting for the calm weather and mount the tortuous Chagres in those frail bongos. There was not a single passenger coach on the line, and more than a thousand men started on that memorable train for Gatun, and from there they reached Gorgona in bongos, and then went on foot or mule back to Panama.

This affair re-echoed throughout the United States, and the steamers abandoned the old anchorage ground of the dangerous bar at the mouth of the Chagres River, and anchored from that time on in the Bay of Limon, for discharging passengers and merchandise, which the railroad took from there to Gatun.

A small town sprang up out of these swamps, and was officially constituted in February, 1852, and named Aspinwall by the Americans, but the Spaniards named it Colon, in memory of the great navigator. The affairs of the company changed at once, money flowed into the treasury, and the work was pushed ahead and was gradually approaching the Pacific shores, to the great joy of the gold seekers who kept on coming.

A great drawback was therefore the lack of workmen, who, from 1850 to 1852, averaged from fifty to three hundred. As hardly had any of them earned enough to pay the passage to San Francisco, they deserted the work for the placers. In 1853, by recruiting in North and South America, in the Antille Islands, Europe, and China, a working force of six thousand men was got together.

In March, 1853, the road had reached Buhio Soldado, 24 kilometers from Colon; three months later, the same reached Barbacoas, 35 kilometers, and in January, 1854, the same got to the Cordilleras, at the pass of Culebra, 52 kilometers from the starting point. During that time the work was also started from the Pacific side, at Panama, the material being brought around Cape Horn to that point, and in January, 1855, the last spike was driven, and for the first time a locomotive, attached to a regular train, crossed the whole length of the isthmus, from Colon to Panama, marking an era in American history as to railroad building, it being the first transcontinental road on our great American continent.

The mortality which reduced the army of the workmen to a considerable extent, was nevertheless not so great as represented, and is used at present as a strong lever against the undertaking of the canal by its opponents and by the friends of other projects. But it must be borne in mind that during the building of the railway, the precautions in regard to a sanitary point of view were sadly neglected. There were no hospitals, no medical staff, nothing to protect the men in a strange, tropical country, exposed to malarial influences, with nobody to care for them in an entirely uninhabited country, a virgin forest; whereas now all along the whole line we find villages, farms, habitations, and comfortable dwellings, easy communications with the two ports, and everything to supply the wants and necessities of human beings—nothing spared in the way of food, nourishments, for the requirements of even the spoiled child of Parisian life and luxury. The conditions of now and then are different. The building of a railroad in 1850 was a greater task to the one of digging a canal in 1880. Such is the progress of our era.

The provisory Panama railroad was in time reconstructed and made solid by the building of an iron bridge at Barbacoas, 200 meters long, at Panama. The road was carried on a trestle bridge quite a distance out into the shallow bay. The roadbed was thoroughly ballasted with rocks from the quarry at Buhio Soldado, where the hard basaltic rock was broken into proper fragments in one of Blake's patented ore crushers or rock breakers. At Colon four wharves were constructed, where ocean steamers could come alongside to discharge cargoes and passengers. The slimy puddles of Colon were filled up, and improvements for a fresh water supply from neighboring springs improvised.

On leaving the main street of Colon, where four lines of railway occupy the whole breadth of the street, the same runs on an embankment for about one kilometer, then it crosses over a viaduct 200 meters long, which spans an arm of a lagoon, being a portion of the main bay of Colon, and named Puerto Escondido.

On reaching main land, the same is covered with mangroves, whose roots above ground, interlaced in all directions, form such an entanglement that it is impossible to penetrate into the forest, which is the home of splendid birds of all sorts of plumage.

At the end of about one kilometer, the road passes over hills of reddish clay, barren and sterile, a very rare thing in those climates. On the heights, however, the vegetation is grand, so bushy, so entangled with lianes, like a virgin forest, and one of them is chosen as the cemetery of Colon.

After crossing the Loma del Mono (Monkey Hill), a ridge of the Sierra Quebrancha, we enter the marshes of Mindi, green with Indian plants and papyrus, and then we follow from time to time the river, which is but a stagnant creek. Gradually the vegetation grows higher, the mangroves get taller, the palm trees more numerous; under the heavy plumage of their leaves fall the pendants of their bright flowers.

Two or three leagues from Colon, the line climbs some meters on the spurs of some abrupt hills, and a cut through the forest allows us for the first time to see the Chagres, wide and slow running. Very soon the river forms a big bend, which surrounds Gatun, a small village of straw huts on a flat plateau surrounded by undergrowth.

On leaving Gatun, the line crosses the river of the same name on a magnificent iron bridge, and enters the pass between Tiger and Lion Hills, two perfectly conical hills with steep sides, covered with magnificent banana plantations. Then we enter again into a marshy plain without mangroves, where high trees succeed to palm trees.

After passing the station of Aharca Lagarto, and near Buhio Soldado, the road enters into a gorge where the Chagres has made for itself a passage between the rocks. Up to

the station of Buena Vista the road follows the banks of the river about 10 meters above the water, then cuts the plain of Frijole. At Barbacoas, near the station of San Pablo, the line crosses the Chagres on a fine bridge, then we reach a prairie, then a small forest with constantly changing fine scenery. We pass through several villages, like Mamei, La Gargona, Matachin, where the inhabitants occupy themselves with agriculture.

The road, on leaving the valley of the Chagres, enters the gorge of the Obispo and crosses two or three times this river, then the pass gets wider, and a second locomotive is attached to the train for the purpose of pulling the train up the slope of the Culebra, and, on reaching the summit, the locomotive is abandoned and we descend on the Pacific side.

We then follow a ravine where the road overhangs twenty meters above the torrent of the Rio Grande, then the valley gets wider and wider and the country more undulating.

The view becomes magnificent, the fine hill of Ancon standing out in profile against the azure blue heavens, and at his base extends Panama, overtopped by the Cerro de Cabras, and far beyond the fine bay, studded with green islands.

The descent brings us rapidly in the midst of a great plain. A small elevation of land, formed by the base of the Ancon hill, raises the roadbed above the marshes, where the sea spreads out at high tide. The forest reappears, but different from the flora of the Atlantic, and in every direction are thickets of cactuses.

We pass through the double row of straw huts of the suburb of Pueblo Nuevo, and a few minutes later the train enters the station of Plaza Prieta, the quarter of the city where the same is built in a curb made by the Gulf of Panama. The town of Panama has about fourteen thousand inhabitants.

After the destruction of old Panama by the pirate Morgan, the governor, Fernandez de Cordova, chose the present site on a high rock, forming a sort of peninsula, easily defended, on the base of the Cerro Ancon, as the site of new Panama. The celebrated engineer, Don Alfonso de Villa Carta, made a strong fort of it, surrounded by heavy, thick walls, several meters wide, and two strong bastions. All of that ancient grandeur is in ruins, and only one of the bastions is well preserved, and is used as a promenade, and on an evening I used to go there to enjoy the sea breeze, the only solace hot Panama has to offer to the stranger of northern climes.

PLOWING IN EGYPT.

WE give a sketch by an artist correspondent of the *Illustrated London News*, drawn recently from life, showing a native farmer at work, and presenting a fair idea of the status of agriculture as now practiced in modern Egypt. It will be seen that the same antique plow of bent sticks, that was used in the time of Moses, is still employed, and that modern improvements have gained no foothold. What this picture reveals in respect to agriculture is typical of the present condition of almost every other branch of Egyptian industry. Little or no progress has been made; but everything is done in the same manner that it was performed centuries ago. "The way in which our ancestors lived and worked is the path for us to follow," says the Egyptian of to-day. His mind, like a true machine, has no tendency to deviate from the direction in which it originally started. It remains to be seen whether the late tremendous thunderings of the British iron-clads will have any rousing effect upon Egyptian lethargy, or whether the nation will continue to live the life of the past.

RECENT PROGRESS IN AGRICULTURAL SCIENCE.

By H. P. ARMSBY.

ASSIMILATION.

In its strict sense, assimilation in plants means the process of forming new organic matter out of inorganic materials by the aid of the sun's rays, and is peculiar to chlorophyll-bearing plants. It will be convenient, however, to give the term a somewhat more extended meaning, and to apply it not only to this process, but also to those related processes which furnish the materials for true assimilation, and to consider in the same connection the kinds and sources of these materials.

Essential Elements—The question what elements are necessary for the growth of the higher plants may be considered as practically settled. A few points may, however, be noted in passing. As is well known, the earlier experiments showed potassium to be one of the elements essential to plant growth, and it was natural that the question should arise whether the functions of this element in the plant could not be performed by other of the alkali metals. Experiments with sodium showed that this element was incapable of taking the place of potassium, and Nobbe has shown that lithium acts as a direct poison to plants. The physiological worth of these three elements increases with their atomic weight; may it not be possible that other elements of the same group having a higher atomic weight may have a still higher worth? An answer to this question has been attempted by Loew,* in some water-culture experiments on buckwheat with rubidium. Earlier experiments by Birner and Lucanus with rubidium, gave very unfavorable results, but according to Loew, the abnormal appearances in their plants were exactly those observed by Nobbe to result from the absence of chlorine; and as only rubidium nitrate was used, it was thought desirable to make similar experiments with the chloride, as well as to repeat those with the nitrate.

The latter gave an entirely negative result; but the experiments with the chloride, in comparison with potassium chloride, though not fully successful, seem to show that at least a certain amount of growth may be made by the aid of rubidium. Still better results were obtained in a third experiment, in which a much smaller amount of rubidium was used, in the form of nitrate, with the addition of ammonium chloride. In both experiments the plants grew well until the time of fruiting, and from then on fell behind the potassium plant. The plant nourished with rubidium chloride formed no seeds, and that fed with the nitrate only one; but whether this was due to abnormal nutrition or to some other cause, does not clearly appear. On the whole the results, though not conclusive, seem to indicate the possibility that suitable quantities of rubidium in a properly constituted solution may be able to take the place of potassium.

Silica in Plants—Another old question which has lately received renewed attention, is that of the necessity or utility of silica to the plant. As regards its necessity, the newer experiments have only confirmed the results of the older ones that silica is entirely non-essential. A somewhat striking proof of this has been given by Hönel† The pericarp of *Litho-*

* Landw. Versuchs-Stationen, 21, 389.

† Haberlandt's Wiss. prakt. Untersuchungen, 2, 160.

spermum arvense is normally very rich in silica, containing from 13 to 16 per cent. of this substance, while its outermost layers contain probably 70 per cent. Höhnel has, however, succeeded in producing, by means of water culture, ripe seeds of this plant containing at most but minute traces of silica.

It appears, however, from recent experiments, that silica, though not essential to the plant, is nevertheless serviceable to it. In Höhnel's experiments it was noticed that the plants grown without silica suffered from plant lice, while neighboring plants which received silica were not thus affected.

Some experiments by Wolff show that silica has more important functions than the simple protection of the plant. Experiments on the growth of the oat plant in aqueous solutions,* continued through fourteen years, have led him to the conclusion that silica favors the reasonable and uniform ripening of the grain by causing the death of the leaves at the proper time, which is followed by a translocation of the nutritive matters contained in them to the seeds. Thus in an experiment without silica, 30 seeds were produced, with a little silica 90, and with much silica 184. Another function of silica was also revealed in some of these same experiments. The experiments were directed toward ascertaining the minimum amount of the several ash ingredients necessary for the production of an average crop.† Thus it was found that the amount of potash could be reduced to about 0.8 per cent. of the dry weight of the plant, that of phosphoric acid to about 0.5 per cent. etc., etc. It was found im-

by plants, as we know that certain nitrogenous organic matters may be.

Some later experiments point in the same direction. Van Tieghem* finds that the embryo of *Mirabilis jalappa* will grow when the endosperm is reduced and replaced by a paste of albumen and water, or of potato starch and water, containing the necessary inorganic nutriment. By microscopical examination and otherwise, Van Tieghem satisfied himself that these substances were actually assimilated. From the brief account of these experiments accessible to the writer, it is impossible to judge of their accuracy or of the weight which is to be given them, and Böhm† on repeating them obtained negative results; but Blociszewski‡ has since repeated and extended them with much the same result as Van Tieghem. Embryos of rye and peas, separated from the endosperm or cotyledons, assimilated starch and sugar, and grew, not indeed as well as those of whole seeds, but decidedly better than those which received no artificial food. The starch grains which lie next to the scutellum of the rye or the epidermis of the radicle of the pea were found to have been attacked and almost entirely dissolved. Embryos of rye also grew when nourished with their own finely ground endosperm, while embryos of the pea grew no better when embedded in pellets of their own ground cotyledons than without this addition. The pea embryos, on the other hand, seemed to be aided in their growth by a dilute solution of asparagin, while this substance appeared to be of no use, or even harmful, to the rye embryos.

It thus appears that plants may assimilate "organic" mat-

place, and an increase in the dry weight of 66 and 69 per cent. in seventeen days was obtained.

Other plants, cultivated in the same soil but with only the atmospheric CO₂ excluded, gained fully twice as much in the same time. In all cases the roots were found incrustated with calcium carbonate. This formation of calcium carbonate, Stutzer suggests, may be explained as due to a metathetical reaction between the soluble carbonates of the roots and the oxalate or tartrate of the soil. The different behavior of oxalic and tartaric acid in these experiments Stutzer explains by a reference to their chemical constitution. Oxalic acid consists of two carboxyl groups, from which, apparently, the plant is unable to appropriate carbon directly. Tartaric acid, on the other hand, contains two carboxyl and two alcoholic groups; and from the latter, according to Stutzer, the plant can assimilate carbon without the necessity of a previous oxidation to CO₂. When the plants were cultivated in a bell-jar containing sodium hydrate, only half the carbon of the tartaric acid could be utilized, and a large amount of CO₂ was found in the sodium hydrate solution at the close of the experiment. In the case in which the sodium hydrate was omitted, however, the carbon of the carboxyl groups was also available, being first oxidized to CO₂ and exhaled, and then assimilated by the chlorophyll grains. Hence, the growth in the latter case was about twice as great as in the former, corresponding roughly to the greater amount of assimilable carbon at the disposal of the plant. A confirmation of this hypothesis was given by an experiment in which glycerine was the sole source of carbon. A

EGYPT AS IT IS: PLOWING IN LOWER EGYPT.

possible however to produce a single plant which contained all the ash ingredients in the minimum quantity. The total ash, it was found, must always be considerably in excess of the sum of the minima of each ingredient. Only when some indifferent mineral substance, like silica, was supplied to the plants, could a normal growth be obtained with the minimum amounts of the other ingredients. The role of silica in this respect can also be assumed by lime or by phosphoric acid; but these substances, especially the latter, are somewhat costly, while silica is present in an assimilable form in all soils in greater or less quantity. It would thus appear that while silica is not essential to the plant, it may be of great importance to the crop by enabling it to make a satisfactory growth in a soil which, without the silica, would not furnish a sufficient supply of ash ingredients, or by preventing a useless consumption of phosphoric acid or other ash ingredients, and an unnecessary exhaustion of the land.

Sources of Plant Food.—That the carbon of vegetation is chiefly supplied by the carbon dioxide of the atmosphere has become one of the truisms of botany; but the question whether this is the sole source of the carbon of agricultural plants and crops, or whether the numerous carbon compounds existing in most fertile soils contribute to any considerable extent to their nourishment is one that has given rise to no little discussion. The well-known experiments of De Saussure and others (compare Johnson's "How Crops Feed," p. 232 *et seq.*) render it extremely probable that the organic matters ("humus") of the soil, may be assimilated

not only when full grown, but also in the first stages of their existence.

A few trials have been made by Stutzer§ to ascertain what classes of organic substances may be assimilated. He experimented chiefly on young plants of *Brassica rapa*, growing them in an artificial soil composed of sand or pumice stone and calcium oxalate or tartrate, moistened with a solution of the needful inorganic ingredients. The plants were placed under bell-glasses, from which the carbon dioxide of the air was excluded. They grew vigorously and gained as much as 228 per cent. of dry matter, thus showing that these acids served in some way as a source of carbon. It was possible, however, that they were first oxidized in the plant to CO₂, which was then assimilated, and to test this a second series of experiments was made in the same way, except that a dish of concentrated solution of sodium hydrate was placed inside each bell glass. Under these circumstances the plants cultivated in the calcium oxalate speedily died, and showed a loss of 4 to 7 per cent. of their dry weight in ten or twelve days, thus showing that the oxalic acid could not be utilized as such by the plant, but must first be oxidized to CO₂. The calcium oxalate remaining after these experiments contained notable quantities of carbonates. The plants cultivated in the calcium tartrate, however, behaved differently. Here a growth took

gain of 126 per cent. of dry substance was made in seventeen days.

As numerous difficulties had to be overcome in experiments of this sort on higher plants, the investigation was continued with chlorophyll-free plants, chiefly with *Penicillium glaucum*, in which, if growth took place at all, it must be at the expense of the "organic" carbon. It was found that oxalic and formic acids, that is, acids containing only carboxyl groups, were incapable of nourishing this plant. Acetic acid and acetates produced an abundant growth, as did also succinic acid. Succinate of iron was also found capable of furnishing carbon to plants of *Brassica rapa* in an atmosphere free from CO₂. Ethyl, alcohol, glycerin, sugar, malic acid, citric acid, lactic acid, and tartaric acid caused an abundant growth of the fungus, as, according to Stutzer's hypothesis, they should do; but butyric acid, valerianic acid, and amyl alcohol formed noteworthy exceptions, neither sustaining *penicillium* themselves nor permitting its growth in solutions to which glycerin or sugar had been added.

Stutzer's experiments have been repeated by Schmöger,* who obtained similar results, but does not regard them as conclusive, since, according to his experiments, the method adopted includes a grave source of error. This source of error lies in the fact that both oxalate and tartrate of calcium are very easily decomposed by the action of bacteria or other organisms into calcium carbonate and carbon dioxide, so that the soil in Stutzer's experiments was a continual source of CO₂. Schmöger found that moist mixtures of

* Jahresber. Agr. Chem. N. F., 3, 216.

† *Ibid.*, 18-19, 1, 250

* Jahresber. Agr. Chem., 16-17, 1, 259.

† Landw. Jahrbuecher, 5, 145.

‡ Jahresber. Agr. Chem., 18-19, 1, 247.

§ Landw. Versuchs-Stationen, 21, 193.

* Jour. f. Landw., 28, 179.

calcium oxalate or tartrate with solution of plant food and with sand (the latter may be omitted) contained, after being exposed to the air for some twenty days, very considerable quantities of calcium carbonate and an abundance of bacteria resembling *Bacterium termo*. Similar mixtures were placed in two flasks, heated to boiling on the water-bath, and stoppered with cotton heated to 120°. Two other flasks were filled in the same way, but not heated. One of each pair was opened after twenty days. The contents of the boiled flask contained no CO₂, those of the unboiled flask 0.234 gramme. After thirty-four days the other boiled flask contained no CO₂, and the other unboiled one 0.2675 gramme. Schmöger also determined the amount of CO₂ absorbed by the potash solution in his vegetation experiments, as well as the combined CO₂ remaining in the soil, and found the two to be approximately equal. In experiments with plants grown in sand alone, the amount of CO₂ exhaled was found to be very small. Schmöger, therefore, concludes that the growth obtained by Stutzer and himself in those experiments in which no potash was present was made by means of the CO₂ exhaled by the artificial soil, and that it is very possible that the small growth obtained in the presence of potash was due to small portions of CO₂ which escaped absorption. At any rate, in the absence of proof that the experiments were really made in an atmosphere free from CO₂, they furnish no evidence of a direct assimilation of organic carbon compounds by the higher plants.

Experiments with such organic matters as are found in the soil have in general given negative results. Detmer* claims to have observed microscopically an absorption of some of the oxidation products of humus (crenic or apocrenic acids) by the rootlets of young peas, and thinks it probable that they contributed to the nourishment of the plants.

Böhm† has sought to solve the question by investigating whether bean plants, freed from starch by long vegetation in the dark, could produce starch when supplied with carbon only through their roots. Negative results were obtained in all cases. No starch formation could be detected, and plants grown in a garden soil containing humus lived no longer than those grown in pure sand (with addition of inorganic nutrients).

Moll‡ has made similar experiments and obtained the same result. In no case was the least formation of starch observed, but on the contrary, starch disappeared from leaves containing it when they were placed in an atmosphere free from CO₂, although they remained in connection with the plant, which grew in a moist soil rich in humus, and presumably containing much CO₂. Leaves were also separated from the plants, and arranged with the basal end in an atmosphere containing about 5 per cent. of CO₂, while the upper end was in an atmosphere kept free from this gas. In some cases an intermediate portion of the leaf was exposed to the air, and in others not. The leaves having been made starch-free in the first place, not the least formation of starch could be detected in the portion of the leaf deprived of CO₂, although it took place vigorously in the other portion of the leaf. Comparative experiments were also made on the rapidity of starch formation in starch-free leaves. A leaf was divided lengthwise just at one side of the midrib. One portion was freely exposed to the air, while the base of the portion containing the midrib was surrounded with an atmosphere containing 5.5 per cent. of CO₂. It was found that this abundant supply of CO₂ to the lower end of the leaf was unable to accelerate at all the starch formation, but that the latter went on at sensibly the same rate as in the other half of the leaf. It was likewise found that the CO₂ of the soil was equally unable to accelerate the formation of starch in the leaves. It would, therefore, appear that CO₂ cannot be transferred as such in the plant, even through very short distances, and also that the organic matter in the soils used by Moll was not able to contribute appreciably to the nourishment of the plants. Corenwinder§, however, has observed that the leaves of a branch of a young chestnut tree, which was inclosed in an atmosphere free from carbonic acid but not severed from the tree, developed normally, from which fact he concludes that they were nourished by carbonic acid dissolved in the sap. Moll's results certainly throw serious doubt on this conclusion, and it is quite as reasonable to suppose that a transfer of plastic materials from the remainder of the tree took place.

The experiments of Böhm and Moll, as well as the very similar ones of Cailletet,|| while they do not conclusively show that plants may not assimilate carbon from organic compounds, do show that under ordinary circumstances and in ordinary soils the amount of carbon which plants obtain through their roots is at least too small to be of any practical significance. The undoubted value of the humus of the soil and of manures lies partly in the inorganic matters which it contains, but to a far larger degree in the solvent action of the carbonic acid generated by its decay, and in its influence on the physical properties of the soil.—*Amer. Chem. Journal*.

RHEA.¶

By J. R. ROYLE.

THE fiber known under the various commercial names of rhea, ramie, and China grass, is one that has, of late years, attracted considerable attention, owing to the rewards which were offered by the Government of India for the best machine or process adapted for stripping the fibrous envelope of this nettle from the stems, and for freeing it from the gummy matter with which it is highly charged.

Efforts to encourage the production of this plant in India were commenced early in the present century, when Dr. Roxburgh obtained a few plants of a species of *Urtica*, which he named *Urtica tenacissima* (on account of the great strength of its fiber), from Sumatra, and from these a great number of plants were reared at the Hon. Company's Botanical Garden at Seebore. The first fiber from these plants was sent to England in 1810, and was very favorably reported on as a cordage material, on account of its exceeding strength; owing, however, to the lack of suitable machinery for its preparation, no further efforts worth mentioning were made for some years. In 1840, Colonel Jenkins discovered the plant growing wild in Assam, and it had, even before this date, been found to be identical with one grown in the Runepore and Dinagepore districts, under the name of khonkhora. Not long afterward, Dr. Falconer and Sir Wm. Hooker were able to identify this *Urtica*, khonkhora, or rhea, as the same plant as that from which the Chinese grass-cloth was made, and in 1854, the Court

of Directors, in forwarding to India a memorandum on the fiber, by Dr. Forbes Royle, directed the purchase of ten tons of rhea fiber annually, for three years, in order to encourage its cultivation. After this, the fiber being well-known in England, it was considered that its further development might be left to private enterprise; events, however, proved that the obstacles to the development of its commercial use had not yet been removed.

In 1869, the Government of India took the matter up, and after obtaining all the information that could be furnished by the Agri-Horticultural Societies in India; and by gentlemen who had been for years engaged in experiments with rhea, came to the conclusion that all the conditions necessary for its cultivation in India on a large scale existed, and that all that was wanted was some machine or process suitable for separating the fiber from the stems and bark of the plant in its green state. They, therefore, issued a notification offering prizes of £5,000 and £2,000 for the two best machines, the merits of which were to be tested in India, the principal condition being that fiber worth £50 per ton in the English market, should be produced at a cost not exceeding £15 per ton in India. The trials were eventually fixed to take place in April, 1872, at Saháranpur, and a plantation of rhea was there established in order that the necessary raw material might be obtainable on the spot. No less than 32 competitors entered for the trials, but at last only one—Mr. Greig—put in an appearance. Mr. Greig's machine was duly tried, but the cost of preparing clean fiber by it was found to exceed the stipulated £15 per ton, while the samples of fiber prepared were valued in London at only £28, and declared fit only for cordage purposes. This being the case, it was impossible to award the full amount of the prize to the inventor, but he received £1,500 in recognition of the merits of the machine.

During the next few years, Dr. Forbes Watson—whose name will always be associated with the attempts to bring rhea into use in manufactures—exerted himself with great energy and success in this country in endeavoring to make the fiber more generally known, and he was fortunate in obtaining a supply of China grass seed, as well as of green stems, which were advertised under the authority of the Secretary of State for India, and distributed to all applicants who were willing either to try to grow the plant or to experiment on the stems. In 1875, Dr. Forbes Watson pointed out the extreme difficulty of inducing any large number of competitors to incur the expense of taking their machines to India in order to compete for a prize, and suggested that trials should be held in this country instead. It was, therefore, at last determined that experiments should be made in London, both with green stems grown in Europe, and with dried stems procured from India, and it was hoped that everything would have been ready for the trials by November, 1875. Several inventors entered their machines for competition, although no prize was offered; but, unfortunately, owing to unforeseen difficulties, it was found impossible to hold the proposed trials.

This being the case, the Government of India, in 1877, issued a new notification, in which, after referring to the prize offered in 1869, and to the fact that the only machine brought forward to compete for it was not considered entitled to the full reward, and had not since been adapted by the inventor to practical use, they proceeded to state that the demand for rhea still continued, and that the conditions which induced the Government at that time to offer a prize remained substantially unchanged. They, therefore, again offered a prize of 50,000 rs. to the inventor of the best, and 10,000 rs. to the inventor of the second best machine or process for preparing rhea fiber; the machine or process to be capable of producing, by animal, water, or steam power, fiber of an average value of not less than £45 per ton in the English market, at a total cost of not more than £15 per ton, laid down at any port of shipment in India, or £30 per ton in England, after payment of all charges usual in trade. The competition for these prizes was fixed to take place at Saháranpur, in August or September, 1879, and it eventually took place in September and October of that year. As many as 24 applications for permission to compete were received, but only 10 competitors finally arrived at Saháranpur, and 3 of these withdrew before the commencement of the trials, leaving 7, viz., M. Van der Ploeg, M. Nagoua, Dr. Collyer, Messrs. Labérie and Berthet, Mr. Cameron, Mr. Amery, and Mr. Blechynden, to compete for the prizes. The fibers prepared by each of the competitors were carefully packed and sent to London for valuing, with the result that none of them were valued at anything like the stipulated £45 per ton; the highest value, indeed, affixed to any of the samples by Messrs. Noble & Co., was £26 per ton. Messrs. Mark Dawson & Son also examined the specimens of fiber, and reported very unfavorably on them, saying that even the best were a long way from being equal to the fiber imported from China. But they offered to pay £25 per ton for one or two tons like some of the best samples, in order that they might put it through all their various processes of manufacture, and see what it was worth. At this time China grass was selling at £50 per ton in the English market.

On receipt of these unfavorable reports, the Government of India felt themselves unable to award the prizes which had been offered; but they made awards of 5,000 rs. each to Messrs. Van der Ploeg and Nagoua, and of 1,000 rs. to Mr. Cameron, the competitors whose samples were considered the best by the English experts. Judging from the reports on the samples, the Government of India came to the conclusion that it did not seem probable that India rhea fiber would be able, at present, to compete successfully with the Chinese product, and that in most parts of India the cultivation of the plant could not be undertaken with profit. They considered that the soil and conditions of climate might be found suitable in parts of Burmah, Upper Assam, and in some districts of Eastern and Northern Bengal; and that if it could be grown in such places, with no more care than is required for a superior crop in an ordinary well-farmed field, it might possibly succeed commercially. They were, however, of opinion that it would be inadvisable to renew the offer of a prize for a suitable machine until such time as private enterprise should have shown that the cultivation of the rhea plant could be undertaken with profit in India, and that there was real need for an improved method of preparing the fiber. Intending growers of the plant can, however, still be provided with roots from the Botanical Gardens at Howrah, for the purpose of starting their plantations.

Here, then, for the present, at least, the matter of the utilization of Indian-grown rhea rests, so far as government action is concerned, but private individuals are still diligently working, and will, it is to be hoped, continue to work until the problem of putting an Indian-grown rhea fiber into the market at a price and of a quality which will compete with China grass is solved. Other countries ap-

pear to be succeeding in pushing the fibers in which they are interested; for instance, the Dutch have lately been sending over consignments of prepared ramie fiber from Java to the Continent, and some bales have lately reached the English market, where they are stated—although not very well cleaned—to compare not unfavorably with China grass. I have not, however, been able to ascertain by what process this Java fiber is prepared.

In Réunion, a French naval surgeon (M. Renaud) has found a process for easily and rapidly preparing the fiber, by means of an alkaline bath, the strength of which is to be tested by Gay Lussac's densimeter, in order to avoid its being so strong as to weaken the fiber; and in Paris, Messrs. Labérie and Berthet have patented a machine which they have worked for some time, and which is said to prepare about 800 kilogrammes of fiber from green stems per day of ten hours. In America, Messrs. Dennis and Angell have patented a machine which is said to be capable of thoroughly and rapidly preparing the fiber from ramie stems, although it was originally designed for jute. According to the most recent advices, this machine has not yet been perfected, and the inventors purpose carrying out some experiments during the coming summer, with a view to its improvement.

Incidentally, it may be mentioned that, in the course of his experiments, M. Renaud claims to have discovered that the planting of rhea among vines protects the latter from the attacks of the *phylloxera*, and even cures those which are already attacked by that dreaded pest. If events should bear out the correctness of this claim, a great boon will have been conferred on vine growers.

In England, numerous experimentalists—some tempted solely by the hope of gaining the Indian prizes, and others, induced by an honest wish to make a valuable fiber more suitable for use by manufactures, and to add another to the list of useful substances with which India supplies Europe—have, for years, been expending money and time and energy, in the endeavor to perfect some machine or process for preparing this fiber for market; but it cannot be said that, as yet, any one has been entirely successful, though many processes have appeared to act remarkably well with small experimental lots of stems.

Time would not suffice, on the present occasion, to give anything like a complete list of all the experimentalists, but, generally speaking, it would appear that those who have adopted the simplest machinery, or processes, have produced the most satisfactory results. Among others who have devoted a great deal of time to the solution of the problem, I may mention that Mr. Sebastian Anderson has succeeded in producing some very excellent samples, in which the separate filaments of the fiber are all as parallel to one another as they were in the original stems. He has not communicated the details of his process to me; but he tells me that he can, with perfect ease, separate the bark and gum from the fiber of either green or dry stems; after stripping the bark and fiber from the stems by hand, he soaks the strip thus removed in a bath, which, while in no way weakening the fiber, thoroughly removes every particle of bark and gum. He has informed me that he is endeavoring to make arrangements for the carrying out of his process in India, and for the transmission of the prepared fiber to London for sale. It is to be hoped that Mr. Anderson's efforts may be crowned with success, but it is worth considering whether, seeing what a continued demand there is for the fiber which comes from China, and which is all hand-prepared, the first endeavor should not be to imitate as closely as possible the Chinese hand-process—notwithstanding its slowness—and to try to forward from India supplies of hand-prepared fiber of as good a quality as the Chinese. There does not seem to be any insurmountable obstacle in this direction, neither does there seem any reason why the fiber could not be grown and prepared as cheaply in India as in China. Above all things, it is to be hoped that experimentalists will not be discouraged by the results of the trials held at Saháranpur, in 1879, and that they will not assume that, because the samples of fiber sent to England as the result of those trials were all inferior, both as regards quality and as regards their mode of preparation, therefore India is incapable of growing fiber of good quality, if only she is shown how to prepare it for market.

The proprietors of the Jugdespore estate, in the Shahabad district of the Patna division of Bengal—the estate or zemindary referred to in Mr. Mylne's interesting paper, which was read before this society last month—thinking it probable that the Indian rhea problem is more likely of solution as a domestic industry than by means of centralized machinery, have been making experiments in that direction, in the cultivation of the plant and hand preparation of the fiber; the results of the former are satisfactory, and the latter has to be introduced into the homes of the people as a new industry. It has been ascertained by experiment that if the green stems are stripped by hand of their envelope of bark and fiber as soon as they are cut, and if the strips are allowed to simmer for a short time in a weak solution of potash, the bark and gum can, with the greatest ease, be scraped or rubbed off from the fiber. Mr. Mylne and his partners propose that this part of the work shall be done mainly by women and children, who will thus be enabled to earn a little money in their own homes; if this part of the scheme succeeds, a great point will have been gained, seeing that the difficulty of finding domestic employment suited to the poorer native women of high caste, who are not permitted to work in the fields, is well known.

The proportion of potash which has been found, after several experiments, to be the best, is about 2½ lb., to every 100 lb. of green strips of bark; and the length of time for simmering varies from two to three hours. Some samples of rhea fiber, prepared by this process by natives in India, have been sent over to England, and valued by brokers at £40 a ton, at a time when China grass was at £48; this is a proof of the success of the hand process, and it also appears that the potash bath when of the proper strength does not weaken the fiber; for some dry bark has been left to soak in the mixture for from ten to fifteen days, after which time the fiber was found to have lost none of its original strength. It is probable that, before long, some inexpensive mechanical adaption may be found, which will supplement or assist the hand process; and with this view, Mr. Mylne is experimenting with some simple machinery, which he believes will enable the women to separate the fiber from the bark much more rapidly.

If these efforts are successful, they will have the effect not only of creating a new domestic industry in many parts of India, but also of bringing into the English market a fiber which will be more thoroughly cleaned, and at a lower price, than heretofore; when this has been done, it will be suitable for a far wider range of manufactured goods than at present. Owing to its scarcity, and consequent high price, rhea of good quality can now only be used to replace, or mix with, silk or wool; but if only the price would

* Jahresber. Agr. Chem., 13-15, 2, 166.

† Landw. Jahrbücher, 6, 327.

‡ Ibid., 18-19, 1, 247.

§ Jahresber. Agr. Chem., 18-19, 1, 299.

|| Jahresber. Agr. Chem., 13-15, 2, 166.

¶ From a paper lately read before the Society of Arts, London.