conditions necessarily indicated by the moraine-heading coarse gravel streams ; and herein lies an important discrimination of the drainage and orographic attitudes of the two glacial epochs.

In addition to the till-like phases previously noted, two assorted deposits were considered. They range in altitude from below the sea-level to three thousand feet and beyond, and vary greatly in individual extent. The great examples are the immense sheets of assorted drift overspreading the great basins of the St. Lawrence, and the Winnipeg basin. These often present, among their surest credentials, overflow channels to the southward, crossing divides often hundreds of feet above existing outlets, and varying in altitude among themselves at least two thousand feet. Some of the more important were enumerated. Reference was also made to the iceward termination of these lacustrine deposits, a phenomenon yet but partially studied. The surfaces of these ancient lakes not only stood at altitudes greatly different from the present, but were tilted, if not distorted, as compared with existing water levels, rising as a general rule, toward the north. Data are being rapidly gathered, in the effort to determine how much of this was due to ice attraction, to ice weighting, to thermal changes, to intercurrent crustal changes independent of glacial presence, and to other and undiscovered causes. Reference was made to the scorings which the glacial floor presents, and some of the more remarkable features alluded to. The number of recorded observations of striae reaches nearly three thousand.

Turning to the more purely intellectual products springing from the glacial phenomena, it was noted that our former ample assortment of theories of the origin of the drift has become practically reduced to one,—the glacial. With few exceptions, the investigators of glacial phenomena in the United States accept as demonstrated the glacial origin of the greater mass of the drift. This is less true of Canadian investigators. Subordinate to this dominant hypothesis, there are various degrees of belief respecting the extent of auxiliary glacio-natant agencies.

Our wealth of working hypotheses has increased as our theory of genesis has become fixed upon the fruitful doctrine of the glacier origin of the drift. The recent introduction of strictly glacial methods has been prolific in stimulus and in interpretation. The working hpotheses necessary for the tracing out of moraines, the discrimination of the tills, the differentiation of the kames, osars, and similar products, and for the analysis of the drainage phenomena, have become rich beyond the limits of convenient statement, and suggestive to a degree unimagined a decade since. Under these, the advance of a year is becoming as the advance of a decade.

If we turn to the broader speculations respecting the origin of the glacial epoch, we find our wealth little increased. We have on hand practically the same old stock of hypotheses, all badly damaged by the deluge of recent facts. The earlier theory of northern elevation has been rendered practically valueless ; and the various astronomical hypotheses seem to be the worse for the increased knowledge of the distribution of the ancient ice sheet. Even the ingenious theory of Croll becomes increasingly unsatisfactory as the phenomena are developed into fuller appreciation. The more we consider the asymmetry of the ice distribution in latitude and longitude, and its disparity in elevation, the more difficult it becomes to explain the phenomena upon any astronomical basis. If we were at liberty to disregard the considerations forced upon us by physicists and astronomers, and permit ourselves simply to follow freely the apparent leadings of the phenomena, it appears at this hour as though we should be led upon an old and forbidden trail,—the hypothesis of a wandering pole. It is admitted that there is a *vera causa* in elevations and depressions of the earth's crust, but it is held inadequate. It is admitted that the apparent changes of latitude shown by the determinations of European and American observatories are remarkable, but their trustworthiness is challenged. Were there no barriers against free hypotheses in this direction, glacial phenomena could apparently find adequate explanation; but debarred—as we doubtless should consider ourselves to be at present—from this resource, our hypotheses remain inharmonious with the facts, and the riddle remains unsolved.

THE ECONOMICAL ASPECT OF AGRICULTURAL CHEMISTRY.

Professor Wiley opened his address with statistics showing the value of the agricultural products of the United States. He then gave figures showing the chemical constitution of the different products, and laid stress upon the necessity of supplying the growing crops with sufficient potassium, phosphorus, and nitrogen. The value of the potash, phosphoric acid, and albuminoids or nitrogen entering into a single harvest he estimated as follows, valuing potash at five cents per pound, phosphoric acid at six cents, and nitrogen at eighteen cents. The total value of each of these ingredients is, then, potash, $598,067,446;

Abstract of an address delivered before the section of chemistry of the American association for the advancement of science at Buffalo, Aug. 19, by Prof. H. W. Wiley of the agricultural department, vice-president of the section.

phosphoric acid, $418,865,930; nitrogen, $2,326,852,674; total. $3,343,786,050.

These quantities of plant food removed from the soil annually seem enormous, but it must be remembered that they are not all lost: much of them is left in the soil in roots, straw, stalks, etc. Those, however, who are acquainted with the method of farming practised in the newer parts of our country know that corn-stalks and straw are generally regarded as nuisances, to be removed as easily and speedily as possible. It is not tilling but killing the soil that is practised. Stables are removed to get out of the way of the accumulating manure, and the corn-stalks are raked together and burned to prepare the field for a new crop. True, in many localities the waste of such a proceeding, especially in nitrogen, is understood. Yet it must be confessed that over vast areas of our agricultural lands there is no conception of the idea of possible exhaustion of the soil, and no systematic method of preventing it. The refuse of the crop, the straw, the stalks, etc., are put out of the way as easily and quickly as possible, and without thinking of the robbery which is thereby committed. The stores of plant food which have accumulated in our virgin soils are indeed great, but they cannot withstand this constant drain on them. The effects of this system of culture soon show themselves in diminished yield, as is seen in the great wheat fields of the north-west and of California, which do not produce at the present time more than half the crop at first obtained from them.

If we place at 40 pounds the annual contribution of potash of an acre of land to the crop, the number of crops which could be produced in a given depth, as far as this constituent of soil is concerned, is easily computed. The weight of dry soil per acre to a depth of nine inches is approximately 3,000,000 pounds. A soil containing .3 per cent of potash would have, therefore, 9,000 pounds, which, at 40 pounds a year, would last for 250 years. But fortunately, by the decomposition of feldspathic rocks and others containing potash, and also by the transfer in various ways of the subsoil to the soil, a provision is found which will prevent the entire exhaustion of the soil. Thus it happens, that, in many parts of the world where fields have been under cultivation for hundreds of years, there is still a sufficient amount of this manurial substance to insure the production of a crop.

Further, it must not be forgotten that there are many manurial substances containing potash which are accessible, and which will furnish immense stores of this substance to the future agriculturist. Chief among these natural deposits must be mentioned the mines of kainit, which have their greatest development near Stassfurt. These mines have already furnished immense quantities of potash, and there is no immediate danger of their exhaustion.

The available quantity of phosphorus as plant-food may be estimated in the same way. The quantity of phosphoric acid in soils varies from none at all to almost one per cent. If we take the mean content of phosphoric acid in a soil to be .15 per cent, the total quantity per acre to a depth of nine inches would be 4,500 pounds. If the contribution to each crop is 20 pounds per acre, the phosphoric acid would last for 225 years without any artificial supply.

The stores of phosphoric acid, however, which a provident past has saved for us, are even greater than the deposits of potash. Apatite is a somewhat abundant mineral; and in South Carolina and Alabama, and other states of the union, are found large beds of phosphates. Some idea may be formed of the extent of these deposits by studying the dimensions of the largest bed of them yet discovered, having its centre at Charleston, S. C. This bed has been traced for a distance of 70 miles parallel with the coast, and has a maximum width of 30 miles. In view of the fact that only preliminary surveys have been made of the phosphatic beds in North Carolina, Alabama, and Florida, and that these surveys have shown the presence of immense quantities of these deposits, it is just to conclude that the mineral wealth of the country, in this particular, is of no mean proportions.

The quantity of phosphates imported into the United States (not including guano) has diminished with the increase of home production, having fallen from 133,955 tons, worth $1,437,442, in 1883, to 27,506 tons, worth $367,333, in 1885.

For the fiscal year ending June 30, 1885, there was exported from the United States farm products having a value of $530,172,835. The value of agricultural products imported was $249,211,975, more than half of which was sugar, tea, and coffee. The excess of exports over imports was therefore $280,960,860.

It must be remembered, however, that the values of exports are given at the seaboard, and are fully 25 per cent greater than for the values given at the farm. To compare, therefore, exports with total production, the sum above given must be diminished by one-fourth, becoming $397,629,626, or 11 per cent of the total net value of the farm production of the country. Allowing for the small quantities of valuable plant-food introduced in our agricultural imports, we may safely place the loss of these ingredients, due to exportation, at 10 per cent of the whole.

The exportation of agricultural products, becomes, therefore, a slow but certain method of securing soil exhaustion; and this accounts for the fact that countries — or those portions of countries which are devoted to almost exclusive agricultural pursuits, thus causing a continuous exportation of agricultural products — become the homes, not of the richest, but of the poorest communities.

It would be useless to deny in this connection that our own country, with a soil enriched by centuries of accumulated nitrogen, has grown rich from its agricultural exports. But when the last of our virgin soil shall have been placed under cultivation, a continuous stream of such exports will certainly impoverish the nation, and reduce all who practise such agriculture to the condition which has already been reached by those who have for years grown tobacco, corn, cotton, and wheat on the same soil, and sold the products without paying back to the field the percentage of profits which was its due. On the other hand, the farmer who is fortunate enough to be permitted to patronize the home market, who sells his maize and takes home a load of manure, adds not only to the plethora of his purse, but also to the fertility of his soil.

Thus, in the light of agricultural chemistry, we see clearly the deep scientific basis of the teachings of political economy which show the value of the home market. While, therefore, the statement that the chief factor in the prosperity of a country is its agriculture, remains in every sense true, yet, from the data discussed, it as readily appears that agricultural prosperity is most intimately connected with the advancement of every other industry. Agricultural chemistry teaches the farmer to welcome the furnace and the mill, for in their proximity he secures a sure return to his fields of the plant-foods removed in his crops.

We have seen by the foregoing discussion, that, without any artificial additions, the soil, excluding the subsoil, contains enough of the two most important and valuable mineral constituents of plants to produce an average crop annually for two hundred and fifty years. In point of fact, however, the impoverishment of the soil takes place at a much slower rate than this theory would indicate. It would indeed be a sorry thought to consider that in a quarter of a millennium more the agricultural area of the earth would be incapable of producing further yields. Doubtless much of this reserve food is brought from the subsoil; and, if it be possible for the subterraneous stores of these materials to gradually work their way surfacewards, even the remote future need not fear a dearth of them.

There is also a certain conservatism in crops, a vegetable 'good breeding,' which prevents the growing plant from taking all the food in sight. As long as there is abundance, the plant is a hearty eater; but, when the visible quantity of food falls to a certain minimum, it remains for a long time without any rapid diminution. This fact is well illustrated in the experiments of Lawes and Gilbert at Rothamstead, where wheat was grown on the same unmanured field for forty years in succession.

Professor Wiley then passed to a discussion of the sources of supply of nitrogen used as plant-food, and, after giving an extended account of the most recent researches, summed up the results as follows: —

1. The combined nitrogen, which is the product of vegetable and organic life, forms the chief source of nitrogen for the growing plant.

2. Before it is assimilable by the plant it undergoes a process of oxidation, which is due solely to a living organism.

3. The nitrates thus formed are absorbed by the plant, and the albuminoids of the new growth are formed from the nitric nitrogen by a process of reduction. The nitrates themselves are subject to the action of a ferment, by which a deoxidation takes place, and free nitrogen and nitrous oxide are evolved.

4. The diminution in the quantity of available nitrogen thus supplied is restored by the fixation of free nitrogen by the action of organisms in the soil, or by the oxidation of free nitrogen by the interior cells of the plant acting in a manner analogous to the nitric ferment in the soil; or by the oxidation of free nitrogen by electrical discharges or by combustion.

5. The quantity of combined nitrogen brought to the soil and growing plant by the rain-water and the atmosphere, arising from the last two phenomena, is an inconsiderable amount, when compared with the whole weight required by the crop.

Since, with a proper economy, the natural supplies of potash and phosphoric acid may be made to do duty over and over again, and last indefinitely, the economist, who looks to the welfare of the future, need have no fear of the failure of these resources of the growing plant. Indeed, it may be said that the available quantities of them may be increased by a wise practice of agriculture based on the teachings of agricultural chemistry.

But with the increase of population comes an increased demand for food, and, therefore, the stores of available nitrogen must be enlarged to supply the demands of the increased agricultural product. It is certain that, with new analytical methods, and the new questions raised by investigation, many series of experiments will be undertaken, the outcome of which will definitely settle the question of the entrance of free nitrogen into vegetable tissues. If this question be answered affirmatively, agricultural science will not place bounds to the possible production of foods. If the nitrofying process does go on within the cells of plants, and if living organisms do fix free nitrogen in the soil in a form in which at least a portion of it may be nitrified, we may look to see the quantities of combined nitrogen increase *pari passu* with the needs of plant life. Thus, even intensive culture may leave the gardens and spread over the fields, and the quantities of food suitable for the sustenance of the human race be enormously increased.

In regarding the agricultural economies of the future, however, it must not be forgotten that a certain degree of warmth is as necessary to plant development as potash, phosphoric acid, and nitrogen. If it be true, therefore, that the earth is gradually cooling, there may come a time when a cosmic athermacy may cause the famine which scientific agriculture will have prevented. Fortunately, however, for the human race, the cereals, the best single article of food, are peculiarly suitable to a cold climate. Barley is cultivated in Iceland, and oatmeal feeds the best brain and muscle of the world in the high latitudes of Europe.

It is probably true that all life, vegetable and animal, had its origin in the boreal circumpolar regions. Life has already been pushed half way to the equator, and slowly but surely the armies of ice advance their lines. The march of the human race equatorwards is a forced march, even if it be no more than a millimetre in a millenium. Some time in the remote future the last man will reach the equator. There, with the mocking disc of the sun in the zenith, denying him warmth, flatheaded, and pinched as to every feature, he will gulp his last mite of albuminoids in his oatmeal, and close his struggle with an indurate in hospitality.

NOTES AND NEWS.

ACCORDING to the report of Gustavus Hinrichs of the weather service of Iowa, that state, since the middle of May, has been subjected to a drouth, the most severe on record. The most serious drouth preceding the present one prevailed during June and July of 1863, when for sixty days no serviceable rains fell in Iowa City; but rains had been sufficiently abundant till the end of May, and nearly five inches of water fell during the first ten days of August. In the early summer of 1886, the last good rain fell on May 13. After that time, there was no rain reaching half an inch until August 4, — eighty-three days without a serviceable shower! The total rainfall during that period was less than one inch, while the normal rainfall would be nearly ten and a half inches. But, notwithstanding this extreme drouth, it cannot be said that there is a failure of crops; because farming operations in that state are so diversified that a total failure is almost an impossibility.

LETTERS TO THE EDITOR.

**** Correspondents are requested to be as brief as possible. The writer's name is in all cases required as proof of good faith.*

Glaciers and glacialists.

THE number of *Science* for the 23d of July last contains a paper by Mr. Jules Marcou, in which he refers to my memoir on Professor Guyot (published by the U. S. national academy), and denies statements cited by me from a publication by Professor Guyot with regard to the latter's glacier discoveries. Mr. Marcou commences his criticism on the subject with the following paragraph: "At Princeton Guyot was long isolated from intercourse with Swiss naturalists; and at the close of his life, while suffering under the malady which proved fatal in 1884, he put forth claims of doubtful value. These are the facts." Then follow the facts as Mr. Marcou understands them.

Mr. Marcou's statement is wrong in important points. Professor Guyot gives an account of his own discoveries of 1838 in his memoir of Professor Agassiz, which was read before the national academy, the first part in October, 1877, the second in April, 1878. This is six years before his decease, while he was still engaged in his laborious topographical survey of the Catskills. The following is the paragraph from the Agassiz memoir: —

"In the spring of 1838 I had the pleasure of a visit from my dear friend Agassiz in Paris, where I then resided. The main topic of conversation was, of course, the glaciers. He put me *au courant* of Charpentier's views, as yet imperfectly published (his book having been issued only two years later, in 1840), and adding his own idea of a general glacier era, he urged me to turn my attention to these phenomena. I asked to be allowed to suspend my judgment until my own observations should justify my adhesion to so startling a theory, but promised to visit the glaciers that very summer. I did so, and an exploring tour of six weeks in the Central Alps rewarded me beyond my expectation. The glacier of the Aar, on which Agassiz began two years later (1840) his regular system of observations, taught me the law of the moraines. The glacier of the Rhone gave me the law of the more rapid advance of the centre of the glacier, and that of the formation of the crevasses, both transversal and longitudinal. The glacier of Gries showed me the laminated, or ribboned (blue bands) structure of the ice deep down in the mass of the glacier, and the law of the more rapid advance of the top over the bottom. On the southern slope of Mont Blanc, the great glacier of La Brenva, with its twin rocks, rising like two dark eyes from the middle of the ice (they are, indeed, called by the mountaineers the 'eyes of the glacier'), made me understand that the motion of the glacier takes place by a gradual displacement of its molecules under the influence of gravity, giving it a sort of plasticity, and not