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ON THE

GENERAL RELATIONS OF SCIENCE

TO

AGRICULTURE,

BY

JAMES F. W. JOHNSTON, F. R. S. S. L. & E.

HONORARY MEMBER OF THE ROYAL AGRICULTURAL SOCIETY OF ENGLAND, AND

AUTHOR OF "LECTURES ON AGRICULTURAL CHEMISTRY AND GEOLOGY."

DELIVERED BEFORE N. Y. STATE AGRICULTURAL SOCIETY.

JANUARY, 1850.

REPORTED BY SHERMAN CROSWELL, ESQ.

ALBANY:

CHARLES VAN BENTHOYSEN, PRINTER.

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LECTURE FIRST.

THE RELATIONS OF PHYSICAL GEOGRAPHY TO PRACTICAL AGRICULTURE.

GENTLEMEN OF THE NEW-YORK STATE AGRICULTURAL SOCIETY : I take this, the first public opportunity which has presented itself to me, to thank you for the very kind attentions received at your hands at Syracuse, and I take the liberty of craving from you, for the series of lectures I am now about to commence, the same indulgent forbearance which you shewed towards the address delivered to you on that occasion. The general object of these lectures is to give you a brief sketch of the relations, the general relations of natural science to rural economy.

It will be impossible for me to fill up a single one of the numerous outlines I shall have occasion to present to you. My purpose will be to impress on you the great breadth of existing knowledge which bears on the farmer's art. And first, to show the character, the true practical position which his own art occupies among human pursuits. And in the second place, to satisfy men engaged in other occupations, that whatever farmers, as a class, may be, in any country, at any time, they ought not, either for their own individual interest or for the interest of the country to which they belong, to be less intelligent, or less instructed in general and special knowledge, than other classes of the community are.

Such a course of lectures is likely to be useful at the present time ; in the first place, because of the position which according to my judgment practical agriculture now occupies in this State ; and secondly, because of the measures which the State Legislature, during the present session, are likely to take—I hope will take in order to improve that condition.

I shall also make it one of my objects to show you that natural science has not only a direct money bearing on the pockets and property of the

farmer, but opens up also large views of the natural capabilities of countries, and of the relations of these capabilities to the comfort and welfare of man; which are not only interesting in themselves, but such as belong to statesmen to become familiar with.

I have on many occasions, in various countries, and in different ways, endeavored to illustrate the very numerous relations which natural science bears to the art of agriculture. It is impossible for any man thoroughly to comprehend all branches of natural science, so as to be able completely to exhibit these relations in all their details. I do not profess such knowledge, and if I did, time would fail me in the endeavor to lay such details before you. I shall therefore select only a few points for illustration—a few points from the broad branches of natural knowledge enumerated in the syllabus already placed in your hands.

The first of these branches, the one I am to present before you this evening, comprehends the relations of *physical geography* to practical agriculture.

Physical geography is intimately connected with physical astronomy, and if time permitted me to discuss the relations of all science to this important art, I might enter on this branch before discussing the subject of physical geography. But the relations which the great phenomena of Astronomy bear to the art of Agriculture, in so far as the seasons—as the alterations of day and night in different seasons of the year, and the modifications of those seasons which similar latitudes are subject to, at various periods of the year—all these are so familiar to you, that I need only to draw your attention to them to convince you that a large branch of knowledge exists here, which it is of great importance that the department of Agriculture should be familiar with.

The most important points in the relations of physical geography to Agriculture, to which I beg to draw your attention, are the following:

First. That latitude very much influences the adaptation of the place to the growth of plants. You know, that if you pass from the southern extreme of this large country northward, you pass over different climates, so to speak; you pass over different parts of the earth, the latitude of which differs. As, for instance, in passing from the extreme south towards Maine, you know that you pass from the sugar and cotton-producing country, into the wheat-producing, and from this to the barley and oat-producing country—which description properly represents Maine—and that whatever is true along the sea-board, is true of all the interior portion, and of all America, from the extreme north to the extreme south; that latitude very materially modifies the kind of culture which it is necessary to adopt to make crops grow best.

On this I need not dwell ; but to show you how very small differences in latitude most materially affect the growth of plants and crops, take one single example. The growth of sugar presents this example. According to the results of experience, the sugarcane will thrive where the mean temperature is from 64° to 67° of Fahrenheit. By mean temperature, I mean that which is obtained by averaging the temperature of every day in the year. If this temperature is from 64° to 67° in any given place, there is the place where the sugarcane will thrive. But though the sugarcane may thrive in such a latitude, and may be cultivated with success where the temperature ranges from 67° to 68° , still, it grows most luxuriantly, and yields the largest return at the least cost, where the mean annual temperature ranges from 70° to 77° . All other things being equal, the countries where the highest temperature prevails, are those where the sugarcane can be grown at the least cost, and drive all others out of the market.

The southern part of Spain, near the Straits of Gibraltar, presents the first degree of temperature spoken of. Here the sugarcane will thrive ; and here was grown the first sugar that came into market. The northern part of Africa has a temperature of the second grade— 67° to 68° , or nearly 70° . There, and in the Azores and the Canary Islands, the sugarcane was cultivated profitably ; and there it was cultivated after southern Spain ceased the culture. But in Jamaica, and other neighboring islands and countries, with which all are familiar, and where the temperature is about 77° , there the sugarcane grows most luxuriantly. But Cuba, and the northeastern part of Brazil, possess the most favorable temperature for the growth of the sugarcane. Thus the single circumstance of variety of temperature, depending on latitude, designates the places where the culture of the sugarcane can be carried on most successfully. All other things being the same, the cost of labor, the energy and enterprize of the people, the institutions of the country—all these conditions being equal—these two countries ought to drive every other country out of the sugar market of the world. But these conditions do not exist ; and in other countries the energy of their population, and the effect of their institutions, come into play, and they may compete successfully even with those most favored by climate for the culture of sugar.

So much for this branch. But the distribution of land and water, is a most important element in the determination of what crops will grow best in countries having the same latitude. You know that all along the seaboard of any one of these continents the climate differs from that of the interior ; and that the climate of the interior of the coun-

try differs from that of the sea-coast, whether of the Atlantic or Pacific side. So in the interior, bordering on these lakes at the north and west, you know that these bodies of water very much modify the climate. All who live near these lakes, know very well that the climate is very much modified by them, that is to say, that the capability of the land to produce certain crops, is modified by the position it occupies on the borders of these great inland seas. You know further, that the rivers of a country have a great influence, not only on the agricultural profit, but on the agricultural products of a country. Suppose the interior of this country were not intersected by these great rivers. Large rivers, are the great highways to market; and you know how little would be the profit to the farmer, who is distant from market, but for these rivers, though he might raise any quantity of grain.

All this I pass over. But a most important point in physical geography, is the elevation of a place above the level of the sea. In various parts of the world there are great ridges of mountains, all of which you are familiar with, as well as with the high table lands, which are to be found in many localities in Europe and America. All these mountain elevations, table lands, and plains, are characterized from certain circumstances, by peculiar agricultural products, entirely depending on physical conformation. These things are obvious and I pass over them.

But the effect of elevations is felt at a great distance. Two illustrations will suffice, on the first, I do not dwell, I will merely name it. Prof. J. here pointed to the map of Europe—to the North sea—to Holland—to the Rhine, tracing its rise in the mountains of Switzerland, until it empties into the North sea, forming at its mouth, islands or deltas. All of you, he continued, recollect the fact, I shall hereafter advert to, of the peculiar unhealthiness of the deltas there. Now, the character of these islands, and of the low country at the mouth of the Rhine, is determined very much by the nature of the elevations from which the water comes. What has been published of the Natural History of your own State, tells you how much the region through which the water flows, determines its quality, what it holds in solution, and how, when it reaches the sea, this matter is deposited in the form of deltas and islands that occupy the mouths of rivers. This is an illustration of the effect of elevations to modify the character of a country, through which the rivers coming from them flow.

But a more striking illustration is presented in another part of the world. The river Nile rises in Abyssinia, flows through Nubia and Egypt into the Mediterranean. It is remarkable that the countries

through which the Nile flows, are bounded by deserts. These countries would have formed part of these great deserts, but for the waters of the Nile. This river rises in the Mountains of the Moon, which are covered with snow at their summits. At certain seasons of the year, this snow melts, and swells the Nile to such a degree as to overflow and cover this vast plain, and fertilizes what would otherwise be barren, thus giving to the soil its capability to grow crops, and sustain a population which, in remote times, was very great. It is interesting to remark how, on apparently small things, which have their connection with distinct branches of human knowledge, the comfort and even existence of whole nations is found clearly and distinctly to depend.

Among the most interesting phenomena of physical geography, are the depressions in certain parts of the world, compared with the level of the sea. I have spoken of elevations; but there are parts of the world, below the level of the sea, which notwithstanding, grow crops and nourish a large population.

I draw your attention to the Caspian Sea. This is a large body of water, from the edges of which, start plains in every direction. This body of water is considerably below the level of the Black Sea and the Atlantic. If any circumstance should happen, by which a connection were formed between the Black Sea and the Caspian, the waters of the latter would be raised from sixty to eighty feet; a very great area of country would be submerged, and the borders of that sea greatly enlarged.

But the most remarkable case of this kind is presented in that part of the world with which we are all familiar by name, and that is Palestine. In the interior of this country, is the Dead Sea, into which the river Jordan flows, through certain lakes, among them the Lake Tiberias. The Dead Sea is twelve hundred or thirteen hundred feet below the level of the Mediterranean. The Lake Tiberias is some five hundred feet below the level of that sea. If any circumstance should open a track or canal from the Mediterranean into the valley of the Dead Sea, its waters would rise twelve hundred feet and drown a large portion of the people of that country, with which our oldest and most sacred associations are connected.

I shall have occasion in a subsequent lecture, to draw your attention to the circumstance of their being certain parts of the world in which no rain ever falls, and certain other parts where the quantity of rain is very small. It is because the rain that falls in this country, bordering on the Dead Sea and the Caspian, is no greater than the evaporation, that it remains as now, and has not been submerged long ago. With

such a climate as you have, and as we have in Great Britain, where the rain that falls is greater than the evaporation, the population of those regions would have been annihilated by the rising waters.

But there are large tracts of country, which are not either above or below the level of the sea ; but which are so flat, that the water that falls, remains and stagnates. In this country, large tracts are rendered useless for agricultural purposes, by the extreme evenness of the surface. In New Brunswick, there are large tracts of this character, and which seem to defy all agricultural improvement.

Again, there is a tract of country on the bay of Chaleurs, which though exceedingly flat, is naturally fitted to become as rich as some of the richest lands of Scotland, even those celebrated for their richness. It is so flat, that the water cannot escape. It is not a bog, or a swamp, but so wet that it cannot be cultivated profitably by the settlers.

Besides these phenomena, there are certain natural obstructions, which present themselves, in the course of rivers, and give rise to new conditions of the country bordering on them, which are more or less unfavorable to the growth of crops, but which farmers make profitable. In New Brunswick, there are many such—which may be called bogs, or swamps. In your own State, in Cayuga county, I believe chiefly on the outlet of Cayuga lake, lies the Montezuma Marsh. I have not visited it myself, but am advised, that the marsh is formed by obstructions, which can only be removed by operations on a large scale, by which a partial drainage is effected, and thus the water enabled to flow from the lake, and thus a large extent of land, capable of being made of the most productive character, may be redeemed from barrenness. In other parts of your country, in Georgia, for instance, there are large swamps, and in Florida, there are what are called everglades ; in regard to which, I am happy to hear, that steps are talked of for draining and reclaiming.

Another remarkable phenomena, which has attracted the attention of physical geographers, is the large deltas formed at the mouths of great rivers, everywhere. Those at the mouth of the Mississippi, are familiar to you all. You know that these deltas found at the mouths of all great rivers, being formed of rich alluvial soils, are generally of an unhealthy character ; unhealthy, because of their richness, and because of that unhealthy character in other situations, and under other circumstances, would not be cultivated at all. If time permitted, I might here show you, how much the agricultural prosperity of a country, not its capability, (for these deltas are capable of the highest degree of produc-

tion,) but how much agricultural products depend on the healthy character of the climate. Farmers thrive in countries far more cold and severe, than others; because these cold and severe countries are mostly healthy. I am sure the hardy farmers, who cultivate the soil of New Brunswick, though they suffer from the extreme cold of the country, and complain of it, yet certainly enjoy far more happiness, so far as happiness depends on bodily health, than the inhabitants of other richer countries, such as Georgia, the Carolinas, Florida, and other southern States, which are far richer, and produce more, with far less labor. Hence, in all cases, in the temperate and colder climates, rural economy in general, attains a much higher state of improvement, than in the richer and warmer, but less healthy countries.

There is one circumstance, in connection with these deltas, to which I will draw your attention, and only one; that is to say, of the lands at the mouths of rivers, and the character of the banks of the rivers themselves, when they are of great width, and when deposits have formed of alluvial soil, as is the case at the mouth of the Mississippi, and in other parts of the world. It is the character of these deposits to assume a higher elevation at the exterior than the interior part; and from this peculiar conformation—the depression of the interior parts—marshes and bogs, and bogs of peat marsh, in some localities are formed in these depressed portions.

I promised to draw your attention to the Rhine. The Rhine, when it reaches the North of Europe, becomes loaded with mud to a great degree—not so great as the Mississippi; but there is this difference: the Rhine empties itself into a bay, where the waters from the north and south-west meet, and a drawing back takes place, and a precipitation of the earths in suspension goes on at the mouth of the river itself. Now, there was a time when these deposits took place without being heeded; when there were formed islands of small extent, the edges of which being raised above the rest, by the action of the waves and the current, formed strips of land on which trees and plants grew—the external being higher than the internal parts—thus forming a large extent of boggy, muddy, and sandy country, stretching from the mouth of the Rhine, north, to the Zuyder Zee; that is to say, forming the country now called Holland. By degrees, the fishermen settled on these little knolls, and their fertility being soon known, the farmers were attracted thither, and by indomitable perseverance and enterprise, these and the adjacent lands were reclaimed by artificial works, and form what is now the limited provinces of Holland. I will not dwell on the history of this people; but you must see that the character of a people in such a country, formed originally by natural operations, and reduced to a

habitable region by human perseverance and skill—you must see in the nature of the country, which must have moulded the character of the inhabitants, and formed the national character of its people—something of their remarkable characteristics. If time permitted, I might enter into details illustrative of these—the result of personal observation in that country—going over its dykes, sailing on its canals, and witnessing everywhere the triumphs of human power and art over extraordinary difficulties, in a country which, from the beginning of the Christian era, has been subjected to continually repeated inundation. Records go back through a period of thirteen centuries, during which there have been great inundations, which have broken up dykes, let out canals, overflowed cities, and drowned large numbers of people, once in seven years. For thirteen centuries, the Hollanders have been subjected, on an average once in seven years, to these inundations. I have thought, in going through that country, how many struggles that people have undergone, what perseverance they have displayed, what victories they have achieved over stubborn and apparently indomitable nature, what effect the consciousness of having done all this must have upon individual as well as national character, and what a great triumph it is in itself thus to have fixed themselves firmly on the soil !

Gentlemen, it is useful to us—it carries with it a great moral lesson—to survey such a country as this; teaching us that those who possess great natural advantages, whether as nations or as individuals, are not always either most blessed or happiest; that difficulties bring out the energies of individuals and nations, and that those nations and those individuals are not only happiest, but in general most successful, who have these difficulties to encounter.

I leave this department of the subject. With the subject of rivers are connected the tides. The flowing of rivers is naturally connected with the flowing of tides, and the flowing of tides is a physical phenomenon intimately connected with agricultural prosperity in many parts of the world. I need not go far for an illustration—if I take you to the Bay of Fundy, which separates Nova Scotia from New-Brunswick—the waters of which rush up with great velocity, and rise to a great height. Fifty or sixty feet is no unusual tide at the head waters of the bay. As they rush up, they sweep the banks on either side, which on the Nova Scotia side are composed of a species of rock and clay, and arrive at the extremity of the bay loaded with mud to a very great degree. They are the muddiest waters I ever saw. This mud is deposited at the head waters of the bay, in great quantities, and forms the richest land existing in that part of the world. The richest land in Nova Scotia and New-Brunswick, is formed of such deposits as these—mainly

from the waters of the Bay of Fundy, which not only bring with them the ingredients that fertilize the soil they form themselves, but bring to the industrious farmer the means to fertilize the upland to a great extent. I do not mean to say that there or in other parts of North America that I have visited, the advantages of these deposits are fully put to use; but still, the means these marshes afford of enriching the uplands is very great, and capable of producing enough to nourish a large population.

But I pass over this also, and I shall take you next to the sea itself, and to the currents that traverse the sea. And here I am able to present one or two interesting illustrations.

Prof. J. pointed out on his map certain shades, indicating the currents of water. Here, said he, (pointing to the coast of Africa near the equator,) the tendency of the water is to flow westward. And here he began with it, tracing the course of what is called the great equatorial current. This current, which is here three or four degrees colder than the water of the main sea, breaks against the northeast corner of South America, and then separates, one portion running to the north and the other to the south. But here, having expended its force it seems to lose itself, but proceeds on till it is taken up to the river Amazon, and flows through the Caribbean sea. Here the water, which before was colder than the surrounding sea, gets warmer, and flows along through the Gulf of Mexico, as if trying to get further west. But it is edged off by the main land, until at last it is obliged to take its way back along the coast of Florida and thence along your sea-board, until it comes opposite the southern part of Newfoundland. When the current comes out of the gulf, it is warm, nine or ten degrees warmer than before. Thence its natural direction is across the north Atlantic, until it strikes the coast of Spain. But it does not all go there; a part of it breaks off and goes north, passing the southeastern coast of Iceland, and then the warm water loses itself in the Arctic sea.

Now, what is the effect of this on the agricultural character of the country which this stream visits? Being nine or ten degrees warmer than the surrounding sea, it retains this warmth to such a degree at the north, that the climate of those northern regions, even as far up as Spitzbergen, is materially mollified by the water thus flowing up from the southern country.

The indications of this, are very distinct in the north of Europe. (Prof. J. here pointed to a map of the globe, across which was affixed a piece of red tape, which followed one of the northern parallels of latitude, or nearly so, saying that it was intended to represent more

clearly the nature of this modifying influence upon climate and upon agricultural products.) That line, said he, covered by the tape, indicates the line where the ground is frozen all the year round; that is the course of the line of perpetual frost. What is the reason of this bend towards the north? (pointing to the neighborhood of Iceland and Spitzbergen, where the tape was carried several degrees north;) the reason is, that the warm water of this equatorial current, being heated in its passage through the Gulf of Mexico, carries this warmth so far north, that it actually changes the course of this line of perpetual frost, preventing a greater part of Lapland and Norway, and a greater part of Sweden also, from being constantly frozen; but for this, these parts of those countries could not bear crops; and in Norway, and a greater part of Sweden, all of Finland, and a large portion of Northern Russia, it would be perpetually frozen, but for the fact that this stream mollifies the severity of the temperature, and thus enabling this northern country to grow barley, oats, and other things, necessary for the sustenance of man. This physical, geographical phenomenon, connects itself with considerations of the highest moment. It shows you, on how slight a circumstance, which might well escape unobserved, depends the fate of a country, and the lives of millions of men.

Suppose for a moment, that this current in its flow towards the west, in search of an outlet in that direction, could make its way through the Isthmus of Panama, and could go right across the Pacific Ocean, instead of being compelled to take its course north, what would happen? This water would flow straight on, through the Gulf of Mexico, into the Pacific. The Gulf stream would cease to exist at the north, and the climate in the regions spoken of, would cease to be modified by it, and we should have an icy desert, without the capacity to sustain human life, and an uninhabitable region in Norway, Sweden and Northern Russia.

To give you an idea of the quantity of heat diffused by the Gulf Stream, in these northern regions, I may mention that the quantity of heat acquired by this stream, and thus thrown northwardly in its course, is enough to warm the whole column of air, that rests on Great Britain and France, from winter temperature to summer heat; hence, there is every reason to believe that the mollifying influences I speak of, are produced in that way.

Another current called the Arctic current, originates in the masses of ice which surround the North Pole. It runs along the eastern shores of Greenland, to Cape Farewell, doubles the cape, and flows up the western coast of Greenland, to about 66 degrees north latitude, where

it turns to the southward, along the coast of Labrador, forming the Hudson Bay current. This, being cold water, very materially affects the climate of Newfoundland. In 1831, the harbor of Newfoundland was closed with ice on the 1st of June, though it is two degrees further south than Liverpool. Arriving at the north end of Newfoundland, it sends a branch through the Straits of Bellisle, to the St. Lawrence, while the main part joins the Gulf Stream, between 43 and 47 degrees west longitude; here it divides—one portion flowing south to the Carribbean Sea, which it enters as an under-current, the other flowing south-west forms the United States counter current. Here it serves a useful purpose. It replaces the warm water sent through the Gulf Stream, and mitigates the climate of the countries of Central America and the Gulf of Mexico, which, but for this beautiful and benign system of aqueous circulation, would have the hottest, if not the most pestilential climate in the world. I believe that the climate of the states of North and South Carolina and Georgia, which is salubrious, even in the summer months, is in a great measure the result of the mollifying influence of this cold current, and thus rendered bearable in those parts of the world, which would be otherwise unhealthy if not unendurable. Another illustration :

I said I would show you why this equatorial current was colder when it crossed the Atlantic. I have already given you one reason, that if it flows from a certain point on the African coast, water must flow to that point, either from the north or the south. Let me show you how it comes from the south. Looking at the map of South America, you will observe the Andes, which traverse the whole of South America, are bordered by a fringe of land on the west forming Peru and Chili; these are low countries—bordered by the sea on the one side, and by the mountains on the other. In these countries no rain ever falls—from their position it should be a country in which nothing was to be seen but barren and sandy wastes, where no people could live, and because of the absence of its capacity to produce crops. Now, there flows from the south-west a large body of water, which drifts up towards the coast of Peru and Chili. It is called the great southern drift. As it approaches the coast of Patagonia, it widens and separates into two branches; one flowing towards the south, the other the north. This current is cold water, and is some ten degrees colder than the sea through which it flows. Humboldt was the person who first observed both the temperature and the effect of this current; hence by some it is called the Humboldt current, by others, the Peruvian current. The effect of this current is very remarkable, upon the agricultural capabilities of

these two countries. You know that rain and mist are caused by the commingling of currents of air of different temperatures. A current of air from the north, meets the southern current, which is warmer and moister, and the mingling of the two, causes the moisture of the air, to be precipitated in the form of fogs and mist, and sometimes to fall in the form of dew. Now the mingling of this warm air, as it passes over this cold current, becomes cooled down. The moment it comes in contact with the current of cold air, it forms a mist, and at certain seasons of the year, a great deal of mist and fog hangs over this whole coast. During the prevalence of these fogs and mists, the atmosphere loses its transparency, and the sun is obscured for months together. The vapors are so thick, that the sun seen through them, with the naked eye, assumes the appearance of the moon's disc ; sometimes as red as blood. This fog is altogether the result of the causes I have mentioned. The effect of these fogs, which cover the whole surface of this coast, to a greater or less extent, and fall in refreshing dews at night, is to cause vegetation to spring up, and flourish, where no rain ever falls, and thus, from these simple, natural causes, this large area, which would otherwise be a desert, is made capable of producing enough to sustain a large population.

In this connection, permit me to draw your attention to another interesting fact. This current combined with the prevailing south-east wind, favors every voyage on this coast from south to north, to such an extent, that one may easily sail in 4 or 5 days, from Callao to Guayaquil, and in 8 or 9 days from Valparaiso to Callao, a distance of more than 1,600 miles. But the same current, flowing north, with the prevailing wind, retards the passage of vessels in the opposite direction. But the last difficulty which arises from the provision made for the sustenance of man, in promoting the growth of that, on which he lives, has been counteracted by human intelligence and skill. The power of steam, or rather its application to the purposes of navigation, conquers this difficulty, and a voyage which it took weeks to accomplish, is now made in the same number of days, and the commerce of this coast, is carried on with great facility.

Another compensation for this difficulty: in order that steam may be employed upon this coast, it is necessary that there should be a supply of fuel ; there is such a supply. At Valparaiso there is a large deposit of coal. Thus Providence, which is always kind to us, and which always provides some way in which human ingenuity may overcome obstacles, seems here to have provided the means for overcoming the difficulties to navigation, caused by this cold current, which is so

necessary to the subsistence and comfort of the inhabitants of that part of the world.

Gentlemen, I might here draw your attention to ancient physical geography; I have spoken of modern physical geography, as it exists now. I might speak of ancient physical geography, as it existed at a very remote period, and show you what currents and drifts existed then, how far they have modified the face of the country, and, in fact, determined not only the capabilities of the soil, but the modes of culture, the crops best fitted to particular localities, the kind of husbandry necessary to their growth. But in this lecture I have trespassed on the time usually allotted to such an address, and therefore I shall not enter on this new subject, but content myself with such illustrations as have been already presented, hoping that the few points which I have put before you, selected from a vast and extended field, will satisfy you that the phenomena of physical geography not only present a vast fund of information of the highest interest, and especially to those whose leading pursuit is Agriculture; but that it does open up very large views of the economy of Providence, which are elevating and improving to the human mind, and which those who have to do with the affairs of nations, above all others, should be familiar with.

LECTURE SECOND.

THE RELATIONS OF GEOLOGY AND MINERALOGY TO PRACTICAL AGRICULTURE.

GENTLEMEN,—The subject of my lecture this evening is, the *Relations of Geology and Mineralogy to Practical Agriculture*. In addressing such an audience as this on such a subject, I can have no apprehension lest my subject should be either undervalued or too little understood. It is under the encouragement of the Legislature of the State of New-York, that the Silurian system of rocks, which is so largely developed in the western part of this State, has been made classic ground among all geologists and paleontologists throughout the whole world; and there is not in Europe a single lover of this branch of natural science who does not feel grateful to you for the liberal patronage you have bestowed on his favorite pursuit. It is very rare that a work so rich in practical and money benefit to the community, as your series of volumes on the Natural History of the State are sure to be, should be at the same time accompanied by so large a harvest of reputation. My only apprehension, in bringing this subject before you, is, that the skilful and extended labors of your own Hall and Emmons may have already made you so familiar with it as to rob of all novelty anything I may have to offer, and to make my illustrations less interesting than they might otherwise have been. But by drawing my illustrations mainly from my own country, with the Geology of which I am more familiar, I may possibly be able, in some measure, to weather this difficulty.

Gentlemen, Geology occupies itself with the crust of the globe; that is, with all the solid materials which we can get at—that forms the subject of geological investigation. Now, the surface of the earth consists of a series of rocks, that lie generally one over another, like the leaves of a book, forming generally stratified deposits, or rocks lying in beds or strata. The greater part of them, though not now lying perfectly flat, were at one time horizontal, but are now generally inclined a little.

Professor J. here pointed to a geological section, where the different strata were represented by different colors, and showing their different inclinations; and went on to say that these strata had certain relations to each other—that is, in regard to position, one being generally highest, and the other lowest. Wherever you find these stratified rocks, the same relative position which they have in one part of the world, will hold good all over the globe, unless where, from some extraordinary circumstance, this natural position has been disturbed.

Besides these stratified rocks which form, by far, the largest portion of the crust of the globe, there are rocks unstratified—rocks which do not occur in strata, but which present themselves in large masses, rocks which when broken, are found to be one solid mass, having no strata. There are many stratified rocks, which are known by different names—but those which are unstratified, and which cover a large portion of the surface of the earth, are not so various. One portion of them is called trap-rocks, which is a dark colored rock, and occurs in great quantities; and another is the granite, of which there is an abundance in your own State. All the north-eastern part of the State of New-York, consists of this granite.

So much in regard to the relative position of rocks—for this is quite enough for our purpose. These rocks have generally definite compositions, or definite component parts; by that I mean a composition which in some cases, is very easily ascertained, and in some cases is characteristic of the rock. Prof. J. here pointed to the geological section of the State, and remarked that this red indicates a sand stone; this blue, a limestone, &c. Now, all stratified rocks, those rocks which lie one above another, as represented on this map—all consist of one or other of three things—of clay, or of sandstone more or less hardened; or of limestone, clay, sand and lime, forming all of the great number of stratified rocks occurring on the surface of the globe. But these are not found always, occurring singly; but sometimes we find sand and clay mixed—partaking of the character of both; sometimes lime is found mixed with either clay or sandstone—sometimes all three are found together; so that these three things, clay, sand and lime, either singly or in combination, enter into the composition and form the substance of the stratified bodies of which I have been speaking. Now you will see from this at once, when I make you acquainted with the further fact, that these rocks presenting themselves above the general surface, are more or less ground down, by the action of the ordinary atmospheric causes; the rains, the ice, and other forces that are continually in operation; you will see, I repeat, that, supposing a

rock to be clay, which is thus ground down, that it will form a peculiar kind of soil—a clay rock will form one kind of soil, and sandstone another, and limestone another, and a mixture of any two of them will form a fourth; a mixture of certain other two, a fifth; and thus you may go on multiplying varieties of soil, from these three kinds of rock, all of them more or less varied, but having the same general character.

Now, practical farmers know very well, that the materials of these different rocks crumbling down, by the action of the causes I have mentioned, will form each a different kind of soil; each of which requires a different kind of husbandry, and each suitable to the production of different crops, varying with the kind of rock that forms the soil. I mean to say, that the husbandry and treatment do not differ in the same degree as the soils; but that because the soils differ, the treatment must differ very much. The clay rocks will give a stiff and moist soil, capable of producing good crops in a hot year; scarcely any in a wet year, but can always be made to produce good crops, when thoroughly drained. The sand stones produce a sandy soil, which is hungry and poor; which will drink up all the water, and eat up all the manure; an easy soil to till, but generally unproductive, except in the hands of a skilful man. Again, if you have limestone rocks, the soil will be not altogether consisting of lime. We have such in England, which is of a rich character, and easily cultivated. Prof. J. here pointed to a geological map of England, on which were represented different kinds of rock or soil by different colors. These colors (he continued) appear in irregular masses, varying as the character of the rock or soil varies, or rather as the edges of the different kind of strata come to the surface. All the stratified rocks being inclined, they present only their edges, as it were, on the surface. If they were horizontal, or nearly so, they would spread over larger, if not the whole surface of the country, and vast tracts would be represented by the same color. But being inclined, the surface is, of course, varied in the character of the soil, and is represented by other irregularities of color. Prof. J. here pointed to a geological map of New-York, presenting to the eye, the similar variations of rock or soil, of which its surface was composed. I was observing, (he continued) that a limestone rock has a soil composed altogether of lime. Such a soil is very rare, but there are some countries where such soils are found. Here, for instance, (pointing to the southeastern part of England) is a soil composed of chalk only. This is one instance where a soil consists in a great part of limestone, for chalk is a variety of limestone. But if, as is frequently the case, limestones are more or less mixed with sandstone, or with clay ground down, then it

forms a calcareous or loamy soil ; and every farmer knows, who has given any attention to the composition of soils, that this is not only an easy soil to till and to plough, but in general, a fertile soil, and a soil which does not need the peculiar management which sandy soils require to make them fertile, nor the drainage which the clay soils must be subjected to, to make them productive.

Let me illustrate these general characteristics of the soils formed by different kinds of rocks, by a more particular reference to this geological map of England. The geologist has shown that the crust of the globe consists, mostly, of a series of stratified bodies having their peculiar general characteristics, and which occur in a certain order, one above another. The studies and researches of the Agricultural geologist, have shown that soils are generally formed from the materials of the rocks that have crumbled down. By studying such a geological map as this, you may see what rocks exist in different countries, and from the combined observation, made by geologists and agriculturists, it is at once seen, by an inspection of these colors, what are the qualities of the soils.

Here, (said Prof. J., pointing to the easterly part of England,) is a purple tint, representing the edge of one of the stratified rocks which makes its way down south, until it is finally washed by the waters of the sea. This rock, consisting chiefly of clay, forms a tenacious clay-soil, of which there is no example in Scotland. It is so strong that it cannot be cultivated, but has laid in grass for a long time, and there is the finest and most luxuriant grass land in England.

Prof. J. here pointed to a yellow tinted strip of land in the neighborhood of Oxford. There, said he, is a bed of clay 500 feet thick. It is soft, but exceedingly tenacious. It forms a soil, which, when exposed to the sun, in a hot summer's day, hardens so much, that it will ring under the stroke of a hammer, and when wet, is so tenacious that the cattle, which walk over it, can hardly draw their feet out of it. Hence in the county of Huntingdon, where a large portion of the surface is covered with this kind of clay, the soil is so difficult and expensive to work, that though the farmers are, on the whole, pretty well off, they complain that they make little or no profit, and that though in a hot summer, they can grow good crops of wheat, in a wet summer they can raise no crops at all. These stiff soils will not admit of profitable cultivation, naturally, though in hot summers, barley will grow well. Practical men well understand why this is so, when they know that a very short period intervenes between the wet and dry seasons, during which

it can be brought to the condition in which it is proper to put the seed into it. This makes it exceedingly expensive land to work, and though thorough draining is now bringing in much of this clay formation, still the land, through the whole extent of country covered by it, bears a very low price, and rents for much less than other lands, being so much more difficult to work, from the fact that the work must all be done in a short period of time, and requires a much larger force to do it, and the crops are uncertain.

Now for another kind of rock or soil. I could give you other instances of clay soil. In Scotland there are such instances, and the Scotch farmers have found out a way of cultivating them; but these are not clay soils, of the character of which I have spoken. Hence it is, that Scotch farmers who have emigrated into this clay region of Huntingdon county, have uniformly failed. I was told of an instance, where twenty Scotch farmers had emigrated into that county, and rented land there, every one of whom went to the wall. So very difficult is it, for a man to change his location, and go to a new kind of soil and country, having only the habits and knowledge, which he has acquired in his own country. If he goes into a new country, without knowing the nature of the new soil, which he attempts to cultivate, or the mode of culture best adapted to it—that man is sure to fail; success only goes with knowledge. A man who has a knowledge of the nature of soils, and the true principles of culture, can go upon any kind of soil in any country and meet with success.

But I said I would take you to another kind of soil. There (pointing to the northern part of England,) is a red sand-stone; here is some of it (pointing to the map) in Scotland—this is red sand-stone, known by the name of old red sand stone. This consists of sand, cemented with clay, presenting a red color, and forming a reddish soil, it is in great part sandy. This red rock (pointing again to the map,) represents Wales. In some parts of that country, it is so sandy and hungry, that it drinks up all the water that falls upon it, and eats up all the manure that is put upon it. Of course it cannot be cultivated with profit in the ordinary manner—but properly cultivated, it can be made to yield very large profits. Supposing, as is frequently the case, a hill of sand stone, is found in the neighborhood of a hill of clay, these two when mingled in proper proportions, form a loamy soil, which is exceedingly fertile and easy to work. This combination forms the whole of the valley of Strathmore in Scotland. (Strathmore means great valley.) These soils are exceedingly rich and fertile, when cultivated with

skill, yielding large profits, both to the landlord and the tenant. To give some idea of the value of this land, I may mention, that this tract, at a period not far distant, paid about £8 an acre of rent ; on an average, it now pays £5, and £6 per acre. The farmers who cultivate this land, have become exceedingly skilful, in the working of this kind of land, it is not difficult to plough, it can be early cultivated in the spring, and the fall rains do not come on so early, as to prevent the proper preparations for the winter grain. These men, who cultivate this land, have become so well attached to it, and know so well the value of it, that they have overspread all this red tract in the northern part of England. By which I mean, that they are all men of the same family or blood, and they have extended all over the region where this red land prevails. They have crept further north into Sutherland, and are now going into the Orkney Islands. On this red land, though the climate is far different from that below, far up into that extreme northern region, they are raising crops of wheat, equal to those of more favorable climates. Knowing as they do well, the kind of tillage the land requires, and the general modes of culture, so that all this land, though lying far north, is of as good a character, in all respects, as that I just pointed to, further south. But after all, it is only in cases of necessity, that they go to these cold countries. It is because they can find no better land to cultivate, and when they can find no more land that suits them here, they emigrate to the New World.

Prof. J., here pointed to another tract of clay soil. This, he said, is a colder soil ; a marsh, covered with peat bog, lakes, and stagnant water, with here and there, rocks, and here and there, cultivated spots. The inspection of such a map as this, tells me, tells you, if you understand the effect of the character of rocks, or husbandry, the kind of culture best suited to particular localities, and which must be followed, if the land is to be cultivated with profit. It tells me, also, what method is to be adopted to improve it. I know that in such a country, the first thing to be done, is to drain it. Then again, if I find one kind of rock, lying at one particular place, I know that there is another rock of a particular character, lying somewhere about it, either far or near, and that a certain other rock, lies under it, either near or remote. See how this bears on the improvement of such land as this. I find that loam is near it ; and this physiology of the country, tells me at once, where to get the materials, with which to improve my land.

It is of great consequence to know more in regard to these soils ; to know more than that it consists of sand or lime ; to know more than that it consists of clay or sand ; it is of great consequence to know whe-

ther it contains more or less, of one or the other of these substances; for, if a particular soil requires lime to improve it, it is quite clear that the soil is naturally deficient in lime. Now, it is the character of this formation, of which I am speaking, that it is deficient in lime. You have all heard of the forest of Ardennes in the northern part of France. It is full of bogs, marshes and lakes, a most inhospitable tract of land. This is precisely the character of land I have described, and which has this feature particularly, of a great deficiency of lime. Knowing that such is the character of the formation, then I know the nature of the soil and the kind of husbandry best suited to it; and, if there be a farmer living there, whose condition is not one of the poorest kind, then I know how the condition of things has been altered, and how the land has been improved.

Recollect, I was just stating, that if lime is to be used as an improver, the quantity to be used is a matter of importance; hence, we must know, how much the soil contains, if any, and hence our analyses of the soils must be more rigid, if we would arrive at safe conclusions on this subject. I have here a table, (which the Professor showed to the audience) copied from one of the volumes of Dr. Emmons, representing the composition of the slates and shales of New-York and other places. Among them, I find some soils, which contain a great per centage of lime. The Marcellus slate contains a great deal. This is a very valuable table, but time will not permit me to go into its details. It is quite well to know, if lime is to be applied to the soil, and a certain quantity of lime is necessary to make all soils productive; if that is to be done, it is well to know, before you commence how much lime there is in the land originally.

I do not know that time will permit me to go into this branch of the subject farther. I proceed, therefore, to draw your attention to the unstratified rocks. In England there are very few trap rocks—there is very little in New-York, but in Scotland there is a large extent of it. These trap rocks are the old lava, thrown up by volcanic agencies. These rocks crumble down and form a very good soil. It is a remarkable circumstance, that wherever these trap rocks are met with, in all parts of the world, they, crumbling down readily, make soils of great fertility, capable of fertilizing other fields in their vicinity. Prof. J. here stated an incident illustrative of this fact. He was visiting the farm of a farmer in Scotland, who was actually taking off twelve inches of the surface of one field, consisting of this soil formed of trap, and spreading it over other fields. This expensive operation he found yielded a good return on the outlay.

Prof. J. here pointed to the north-eastern part of New-York, where the granite occurs. Granite yields a poor soil, which is sandy and hungry, consisting chiefly of gravel and sand, which does not present great attractions to the farmer, and in the old country is left to be improved and settled when there is no other to cultivate.

Here, said Prof. J., let me take an illustration or two from your own country. You know that a wheat country consists of a soil formed of rocks, represented on the maps by a particular color, chiefly of limestone. He then pointed to another strata, representing a hungry sandstone, then to another, representing the Helderberg limestone. Of all the rocks, this forms the most fertile soil; it is a strong soil, not difficult to work, and retains the water which falls upon it. He then pointed to a clay series of rocks, which do not produce a fertile soil, but when mingled with the sandstones they form a pretty good soil. The limestone, which is in itself a good soil, mixed with clay, forms a great Indian corn growing country.

One point I desire to bring under your notice. I have told you that if a series of rocks be represented by my four fingers, they always occur in a certain order, one above another—here is a sandstone and there a clay; this order is never inverted. This is a matter of very great importance, with reference to the flowing of the water from one end to the other of these strata, because it is obvious that by this means, what is a sandstone at one end may become a clay rock at the other. The Helderbergh series consists of clay and sandstone. Towards the west it is clayey, and towards the east it is silicious; hence the soil is different as you proceed from west to east, so that the geologist not only requires to know the relative position of one rock to another, but whether the rock is liable to these changes in its composition. Hence it is often difficult to determine absolutely, from an inspection of the geological map, the precise quality of the soil in different positions.

One or two other illustrations which the United States present. If you go south into Alabama, and pass from the rich alluvial soil of the sea-islands, over this whole extent of country, from south to north, you find nothing more convincing, from the different qualities of soil and their capabilities of producing different kinds of crops, of the fact, that the geological structure of the country, determines its agricultural products. I must draw your attention, in this connection, to France, which presents another remarkable instance of the relations of Geology to the general fertility of a country. M. Sullin in his "*Voyages Agronomiques*," has divided France into eight regions, according to their fertility and agricultural productions. Climate, in so extensive a country,

has no doubt something to do with the fact, that the vine and Indian corn do not flourish in the first of these districts, that of the north; and with the other fact, that the region of the south is also called that of olives. But it is nevertheless remarkable, that this country divides itself naturally into as many geological regions, almost coincident with the agricultural regions of M. Sullin, and thus geology and practical observation are coincident in their results.

Another point will admit of considerable illustration, but I can only spend a moment or two on this head. I have spoken of the composition of soils and the great differences which exist between them; I have spoken of clay as forming one great group of soils. But here is a remarkable distinction. The same kind of material may under different circumstances, present different varieties of soil. If I take this piece of clay, and go into the market, offering a farm for sale, and saying, I have a farm of this kind of clay, the answer would be, we want nothing to do with your farm; but if I tell a farmer, here is another farm, of this soil, holding a piece of dry clay, he will at once say, I will go and see it. Thus the simple inspection of these two kinds of soil, will tell any practical man, that they are more or less suited to cultivation. In Scotland, we produce magnificent crops on these clay soils. These clay lands, being drained are thus rendered capable of culture, and this depends, not on any new chemical combination, or change, but on the state in which the material exists. It so happens in all parts of the world, that there occur rocks of the same material, which are sometimes harder and sometimes softer; then again there are rocks which are called metamorphic, which have been analysed and found to contain the same elements, and yet are so different in their physical character, that when in one form, they are capable of growing green crops—in the other fitted for wheat. This is an important point and has an intimate connection with the deductions drawn from an inspection of a geological map. I should have liked here to have drawn your attention to the modifications which the action of water has produced on the character of the soil. I showed you in my previous lecture that there were currents in the sea, and how they affected the atmosphere and the agricultural capabilities of various large sections of the globe. But, I did not then speak of the transporting action of these currents. They carry along with them icebergs on their surface, and gravel and sand at the bottom depositing them in various places on their route. And when I remind you that this part of the world (pointing to the northern part of America,) was once below the level of the sea, and that the Arctic current swept over it, with all the rocks and substances with which it

was charged, spreading them wherever it went, you may well expect that traces of this current may be found on the surface of the globe. This is the case, we find in the Genesee Valley, not only the materials which now form the bottom of Lake Ontario, but we find that these materials essentially modify the soils of this part of the country. It is an interesting and curious fact in the Geology of your State, this Arctic current swept through that valley, and carried the materials which it brought with it over a large surface of country. All this is a matter of interest, because it shows you that a knowledge of these drifts, and of the loose materials which they bring with them is as of much consequence as a knowledge of the rocks themselves. I shall have occasion to revert again to this subject, I pass over it now; I could present, if time permitted, many illustrations of the effects of this current on the agricultural character of other districts.

I have shown you the general application and relations of Geology, to Agriculture, and how the kind of rock determines the quality of the soil, but there occur in these rocks, mineral substances of various kinds. Now a knowledge of these substances, is an essential branch of geological study; if you find in any one rock, that there occurs a certain mineral substance, you have acquired a knowledge of the composition of that rock in every other country. If you find in any one country, in England for instance, what is valuable as an ingredient of the soil, you may well infer that the same thing exists in other countries, in rocks of similar character. One word of explanation; if I light a match, an ordinary lucifer match, a white smoke will be observed; at the end of this match, there is a little phosphorus, that white smoke, is the smoke of the phosphorus, and the substance produced, is phosphoric acid, it is a white solid substance. This phosphoric acid, combines with lime, and forms phosphate of lime. If I take a piece of bone and burn it, it will blaze for a while, and bye-and-bye it will cease to burn, but the part of the bone that is left, is bone-ash, and is white. This bone-ash, as you all know, is phosphate of lime. This phosphate of lime exists in all bones; it is also found in the earth; there are certain geological formations in which it has been lately discovered in considerable quantities. In my subsequent lectures, I shall show you, that this is an important material in the hands of the practical farmer. In the eastern corner of England, there is a rock, called Crag, consisting of sand and shells, among which were found lumps, which when examined, were found to consist of this phosphate of lime. All know that bones are employed as manure; they contain phosphate of lime; now if that be the case, it is obvious that if you can get it in the form of a mineral, and apply it to

the land, it would be valuable to you. Some farmers are in the habit of employing guano; but this phosphate of lime has been found by experiment, to be equally good; and when I tell you that this phosphate of lime, thus dug out of this formation, had been known to practical manufacturers for years, who had all the machinery for getting it out, and grinding it down, and that they are kept fully employed in preparing it with sulphuric acid, in the form of super-phosphate of lime, you will see that it must be an important material to the farmers. When you learn that the manufacturers are making money by selling this substance to the farmers, who in England, do not throw away their money in experiments, you may be sure, that there is something in it. Now, wherever that rock occurs, it is very probable that that substance is found in it. Professor J., here pointed to a green sand soil, which he said was found in the southern part of England, and was remarkably productive of wheat. All have heard of the marl pits, which exist in this neighborhood, and the materials of which, for hundreds of years, have been dug out to fertilize the land. In this marl are found little nodules, that consist almost altogether of this phosphate of lime; here also, are found bodies of marl, five and six feet thick, containing six per cent. phosphate of lime; knowing this, you have a clue to the fertile character of the soils in this region.

Professor J. here related an anecdote, illustrative of the great fertility of some of the hop lands of Surrey, of the great value of the hop crop, all of which was the result of the application of this fertilizing substance, or of its existence naturally in the soil. This phosphate of lime, he continued, explains this productiveness. Wherever this green-sand comes to the surface, there you may look for these same phosphates, and there you may look for good crops. This green sand occurs in France and Germany, and other European countries. In New-Jersey, in this country, you have a green sand, which belongs to the same class as ours in England.

Now, gentlemen, you see how important the indications of Geology are, in showing where to make selections of lands for farming purposes. If, among your tertiary rocks, you find anything analogous to this sand, you know that you have found a valuable fertilizing material. Then there is another mode in which this phosphate occurs. Limestone occurs in all countries; its qualities are various; some contain animal remains; the bones of animals contain phosphate; therefore it is a matter of great importance to know which of two limestones contains the most phosphate. I shall show you, in a subsequent lecture, the decrease of crops from the absence of this phosphate in the soil, and how, by

restoring this ingredient, the land may be restored to fertility. In Scotland there is some limestone that has been found, by experience, to be better than others; and it turns out, by experiment, that it is in consequence of the presence of more of this phosphate in one than in the other. I have alluded to the existence of green sands in your country. I learn from Professor Emmons and from Professor Hall, and Professor Logan of Canada, that there are great quantities of this phosphate in different parts of the country; that it exists at Rossie, and that the iron ore of Clinton county contains this phosphate of lime. If it be true that it has been found profitable to buy this phosphate at six and ten pounds sterling per ton, it cannot be unprofitable to inquire whether, in your country, the material cannot be found in quantity enough to bring it within the reach of farmers; and I am happy to find that there are many inquirers in this State who are eager to explore and find out this material which has been found so essential to agricultural improvement. You see, said he, how wide a field this subject opens—you see that the application of physical Geography tells on the pockets of the farmer, and teaches him how he may grow larger crops. This, after all, is the test of the value of science, when applied to the practical affairs of life. Unless you can show the practical farmer—I speak of the farmers of England—that this will tell on his pocket, you will scarcely prevail on him to give it his attention; but when he convinces himself that such and such a process of tillage or manuring will actually enrich him, then he is ready enough to follow your suggestions. I believe that before we get through, you will find that this subject touches, very nearly, the pocket of the farmer.

LECTURE THIRD.

THE RELATIONS OF BOTANY, VEGETABLE PHYSIOLOGY, AND ZOOLOGY, TO PRACTICAL AGRICULTURE.

GENTLEMEN :—The subject of the lecture for this evening, is the relations of *Botany*, *Vegetable Physiology*, and *Zoology*, to *Practical Agriculture*.

If the other subjects, of which I have treated in the preceding lectures, were far too wide to admit even of a sketch or outline of them in a single lecture, I am sure you will appreciate the necessity, if I crowd into one lecture the three subjects which I am now about to bring before you, of my being even more brief and desultory than heretofore.

First, as to the general relations of Botany. You will bear in mind, that as botany is the science of plants, it must have a close relation to the culture of plants, and as far as these general relations are concerned, they involve the natural relations which all plants have one to another.

The general natural relations of plants are such, for example, as that all the different kinds of corn plants, commonly known as cerealia, and all the grasses, producing seeds of a similar character, possess nutritious properties of a similar kind. The potatoe possesses a nutritive character, different from the corn plant. This, however, is not so important a matter, as it is to know that the entire family to which the potatoe belongs, all possess a similar character ; so that, if you know the character of one, you know the character of the whole group of plants. So far as these general relations are concerned, the subject is familiar enough to all, to lead them to conclude that it is one of considerable interest to the practical agriculturist.

Nor shall I enter into a minute analysis of the nature of plants, a province peculiar to the medical man who knows what substances belong to particular plants, and in what plants he is to look for peculiar medicinal properties.

Nor can I do more than bring to your notice the uses of Botany to the art of Horticulture, giving new esculents to the gardener, bringing

new flowering plants, and new ornamental shrubs into your gardens, and teaching us how to transfer successfully, plants of value and beauty, from the climates in which they naturally grow, and how to realize its importance to arboriculture, a branch which you do not follow as we do in England, because the extent of your natural forests, rather gives you employment enough, in cutting down than in rearing up, but which in many parts of Europe, is an engrossing pursuit, and has led botanists into all parts of the world, in search of new trees; and thus the newly discovered continent has been made to contribute to the beauty of the forests of the old.

Passing over these relations, at which I can merely glance, I must now draw your attention to the structure of plants, and to a description of their organs. In investigating the structure of plants, that of the leaves becomes essential, to know as well how plants live, as how they should be fed; that is, to those who are desirous of understanding the principal branches of knowledge, on which all sound agriculture must be based. Among the circumstances connected with the structure of plants, the organization of the leaf is of the greatest importance. The upper side differs generally from the under; when subjected to the magnifying power of the microscope, this difference is very striking. The under part of the leaf is found to be studded with little holes, or pores or mouths, which sustain important functions or relations to the life of plants. They are very numerous. To give you some idea of their number, I may mention that on a square inch of a single leaf, twenty thousand of these little pores have been seen and counted. The number of these pores indicates to those who have studied this subject, the circumstances of climate and atmosphere to which the plant is adapted.

Prof. J. here pointed to a diagram representing, on a large scale, the form of the pores of three different plants, showing their difference in size and shape. This peculiar structure, continued he, is so intimately connected with the functions of the leaf, that I must dwell upon it for a moment, to illustrate in what manner plants live, so far as their growth depends on the air. By means of these pores, they suck in aerial food from the atmosphere, the mode in which they drink it in, the quantity and the circumstances under which they absorb it most favorably, that is, the circumstances of temperature and moisture, are related to the form and number of these pores, as they occur in particular kinds of leaves.

The structure of the stems of plants, is also one much connected with their growth. Those who have the curiosity to examine the structure of the stems of plants, have only to turn to Prof. Emmons' volume

on the Agriculture of the State, where sections of plants and trees are given with great accuracy and beauty. These, as Prof. E. well says, exhibit in a strong light, the important relations which science bears, to the practical cultivation of these plants.

The structure of the roots of plants, is another important point, requiring a minute study into the manner in which the stem, tapers down into the extreme fibres of the root, of the spongy form of the extremities of the roots, which enables it to draw to it, all of sustenance that it gets from the soil. Thus the habits of these roots are important. Some plants spread their roots over the surface, as the turnip, which spreads its roots to the distance of four or five feet. You may readily trace them to the distance of three or four and even five feet, showing from how great a distance these plants draw their sustenance. Some plants descend to a great depth. This is another important point; for if the habit of a plant, is thus to go down to a great depth, and if the deeper it goes, the more food it extracts from the soil, then it is quite clear, that the more shallow the soil is kept, the less the farmer has studied the soil.

Now among the plants of this habit, wheat is one that will send its roots three or four feet into the soil, in search of food; and the more mellow the soil, the more easy is it to get the food, which enables it to grow to a great height and to reach its maturity. Hence a knowledge of this fact, in regard to wheat and flax, suggests the necessity that the soil should be deeply cultivated—that the farmer should plough deep, in order to avail himself of this store-house of natural food, which is essential to supply the wants of the plant and enable it, through the medium of its roots, to bring this food to the surface and make it useful. Thus, some plants have roots so formed, that they will grow only in light soils—others in stiff soils only. Wheat requires a strong and stiff soil—the barley and the turnip a light soil, and this fact indicates that where a farmer has only a strong soil, he must lighten it in order to grow barley or the turnip; and that some soils must be drained in order to cultivate these two things.

On the other hand, the different kinds of plants indicate to the skilful man different kinds of soil. If I had a geological map, and if time permitted, I could have shown you how certain plants indicate certain geological formations; how I could know from the kind of plants growing on a particular spot, of what rocks the soil was formed, and what kind of rocks I could there look for with certainty. I have here a list of different plants, with the different geological formations on which they are found; but I cannot dwell upon it. I have a list of trees also, which

are peculiar to certain formations; but I prefer to draw your attention to the agricultural indications of plants.

Certain plants, (the names of which I need not give, as they are scientific names, and require a knowledge of Botany to understand them,) certain plants indicate certain soils, as the thistle indicates a rich and productive soil—keep down these thistles and you have a good soil. Brambles indicate a loamy soil; the wild radish, a poor soil; the rush, a good soil, but one that is useless for want of drainage; the common rag-wort, which occurs in arable lands, indicates that the land is badly cultivated.

Then you all know that trees indicate different varieties of soil. The beech, a light soil; maple, also a light soil of a very superior character. I have here a list of forest trees, and the different formations which they severally indicate, but I need not dwell on this part of the subject.

The habits of plants, particularly of those which infest the soil, are important as teaching us how to exterminate them; that is, it is important to know whether they are annual, biennial, or perennial. Those that are perennial, like the Canada thistle, indicate from that fact how they are to be exterminated; if annual, they must be kept down every year; if biennial, they must, to be exterminated, be attended to once in two years. Perennial plants require to be more effectually exterminated, according to the character of their seeds—as, for instance, whether they are strong, and will remain long in the ground without rotting. The seed of the pigeon weed, for instance, is of this character, and may be carried to great distances without being destroyed. This vitality of seeds, therefore, is of great consequence to the practical man.

Again, the mode in which plants are propagated is another subject of importance. Many of them are propagated only by seeds, and if you destroy the seeds, you are certain they will not appear again. But there are others which are propagated not only by seeds, but by running roots; of this character is the Canada thistle, so that if you cut down the plant, before the seeds are ripened, the roots will propagate and increase the crop. So with the common twitch grass; the more you cut it down, the more it will grow. These facts bear closely on the practical operations of the farmer, and in this respect botany has a direct and a special reference to the art on which the farmer lives.

I need not go farther into details, to convince you how far an ignorance of botany stands in the way of progress in agricultural pursuits. But there are many different kinds of plants, which botanists study, which are of particular interest to the practical farmer, or which, at least, possess as high an interest to them, as any other.

I may mention mildew, smuts and rust. This is a subject of the highest interest. By examining them closely through the microscope, botanists have discovered how they grow—what they are—how they propagate—how they get into the plant and seed—and how they may be exterminated. It is obvious that to exterminate smut, you must either destroy the seeds, when they have come to maturity, or destroy the plants before they have attained that state. But of all the smuts or fungi, as they are called, that injuriously affect plants, the potato disease is one of the most remarkable; and when we consider how important a root, potato is, and what great distress has followed the effects of this disease, you cannot fail to see that this branch of knowledge, the province of which, is to investigate the causes of disease like this, is deserving of all possible encouragement. And though no study arrives at maturity at once, still, because we cannot discover everything in a moment, or by as short a process as we could wish, we are not, on that account, to discourage these investigations.

Among the various kinds of smuts, affecting corn plants, that which affects Indian corn, is the most remarkable. I have never seen its effects myself; but it is described as remarkable from the fact, that it can only be exterminated, by selecting the seed from localities not affected by it, or by cutting it out as soon as it appears. But the most singular and interesting, is that kind of fungus that affects rye. It affects the ear of the rye, and the affected grains assume an appearance, not unlike small spurs, sticking out. This ergot of rye, as it is called, shows itself in most places, in low, wet and marshy lands, where rye is grown; or in better land, in seasons of great rain, succeeded by great heat, and generally in moist years. When rye is affected in this way, the ergot being ground up with the flour, produces disastrous consequences, and persons have died who have eaten the bread made of it, under circumstances of disease of a remarkable character. In consequence of this discovery, this substance has been introduced into the list of medicines, and employed with effect in certain cases. But it is a curious fact that this same ergot is found not only in rye, but in various kinds of common grasses on which cattle feed, particularly among the rank grasses that grow in marshy places. It was immediately inferred that this kind of fungus, thus produced in these grasses, on which cattle feed, and which, in rye, produced the remarkable, feverish effects on the human body, was the cause of similar effects in cattle—which in many districts prevails to such an extent that the farmers find it impossible to secure calves. Of course, the remedy suggested is, the removal of the cause; and that is done by draining the marshes on

which these rank grasses grow. There are none of you who may not see, that the application of the results of this branch of study, has a direct bearing on the practical, pocket interests of the farmer, as it enables him to avoid evils and prevent losses, to which he must be otherwise liable. I pass over any further illustrations on this subject of Botany, with a single additional remark: that this branch of science, in connection with Chemistry, to which now may be added, the modern science of Histology, has led to important results, in reference to the cultivation of plants.

Prof. J. here pointed to a diagram representing on a large scale, sections of the common carrot and beet. This is done altogether by the microscope, and they are faithful delineations, but if you apply to these small cells, which cover the surface, chemical substances, you can produce changes of color in one part and not in another; and knowing what kind of vegetable substances are lightened in color by chemical substances, you draw conclusions as to the nature of the substance itself, though the particles are so minute that the chemist could not extract them for examination. This constitutes that branch of science called Histology, and being applied to plants and animals, makes us acquainted with their entire nature, and on what circumstances these changes, when healthy and when diseased, must depend.

I pass on to Zoology, and you cannot but perceive that the science that develops the general habits and structure of animals, the natural relations of one to another, and the functions of their several parts, how they live, and how they live best, must be of importance to the agriculturist, and particularly that branch of it which relates to breeds of stock.

As to breeds of stock, a knowledge of Zoology is necessary to understand what is a breed, what qualities characterize different breeds, to know how to distinguish one breed from another, and how to preserve them pure—for the excellence of breeds is determined by the skill of the breeder. The physiology of animals is another branch, but want of time will not permit me to advance even the reasons necessary to satisfy you, that a knowledge of the diseases of animals involves a knowledge of the structure and habits of the animals themselves; and particularly that the knowledge of the habits of animals that we desire to rear, is of great consequence in the feeding of stock. To know that the absence of light, and of all causes of disturbance and irritation promotes the fattening of animals, is of consequence. To know that the warmth of animals will enable you to save a portion of the food which

would otherwise be necessary, and to keep more stock than could otherwise be kept, that you can keep some stock in better condition than others, if warm ; these are matters of importance. I do not know how your cattle houses are looked after, but in New-Brunswick, I know that great attention is paid to this matter, and that the cold is carefully excluded from them. Exercise also wastes the substance of an animal, and he who would save the food, must avoid unnecessary exercise of his stock.

I do not dwell longer on the relations of Zoology to this department, but proceed to draw your attention to Entomology, or the study of insects. This study has been brought so prominently to your notice, in the Natural History of your State, that you cannot fail to see, that it is of great consequence to the practical farmer. There are insects which attack our orchards. The apple tree is liable to this attack ; peach orchards are also liable to the attacks of certain insects. In England and Scotland, the forest trees are liable to these attacks. The Scotch firs particularly are subject to such attacks. Some sixty acres, covered with this tree, were in one instance completely destroyed by insects. The mountain-larch was, in one season, attacked throughout the whole island, and millions of these fine trees destroyed by insects. There are insects also which attack our crops. The wire-worm, every farmer knows ; the turnip beetle often destroys whole fields, so that the turnips have to be sowed over and over again. Then there is the wheat fly. You, in the northern part of America, for many years have been subjected to the visitations of this insect. I should like to illustrate how serious these visitations have been. I have here notes of the progress of the wheat-fly in different parts of the United States, during the period alluded to ; but in a recent volume of your Society's Transactions, I find an able paper on this subject, by Dr. Fitch, which precludes the necessity of going into details. I may state, that since 1842, it has spread from the east to the west, from the east to the north, and that its ravages have been more or less destructive in certain localities, gradually putting a stop to the growth of wheat, until during this last year, the wheat crop was scarcely touched at all ; but in New-Brunswick it has ceased to be cultivated.

I said I should like to draw your attention to the effects of the attacks of these insects, where they have pervaded whole districts and exterminated almost, certain crops, and sometimes changing the system of cropping and husbandry. I take a single illustration in the case of Canada, and I shall present to you on this board two or three numbers, to show how striking have been the effects of the ravages of this fly on

the habits of a people, and on the nature of the exports of the country. Prof. J. here marked on the black board, the relative proportions of wheat and oats raised in Canada in three different years.

	1827.	1831.	1844.
Wheat, bushels,.....	22,981,244	3,404,756	942,835
Oats, bushels,	2,341,529	3,142,274	7,238,753

The most striking change, is that between '27 and '44, between the two main crops. This diminution in the wheat crop, indicates many things, melancholly to contemplate ; not the least of which is, the individual misery and suffering, to say nothing of the loss of property which this change in the kind of husbandry, has brought upon the people visited by this insect.

Now there is only one other point, in reference to which I would call your attention, and that is, Microscopic Entomology, and the use of artificial means of investigating the nature of these minute animals, which can not be seen by the naked eye. First, in regard to the nature of these animals. If I take a little pure water, and place it under the microscope, I can perceive nothing like animal life in it ; if I put a few grains of pepper into it, you will see the water teeming with minute animals, which are now named infusoria. This is produced by the infusion of the vegetable ; hence the animals are called infusorial animals. They exist in all river and sea water, in large quantities. The number of their species and genera, are very great. It has been found that those which live in the salt water, will not live as readily in the fresh ; and when the fresh and salt water mingle, a change takes place, and the animals die in great numbers. They are naturally, short-lived, but this change of water causes them to die in greater numbers than usual ; and mingle with the mud carried down by the rivers, and deposited where the fresh and salt water meets ; thus forming those rich deltas, at the mouths of rivers, of which I have spoken in a former lecture. These rich deltas, as I have told you, are formed in part from the kind of material brought down by the water, from the different geological formations, near its source, but the extreme richness which characterises them, where the fresh and salt water meet, arises from the circumstance, that there is a great deal of this animal matter deposited on these deltas, and there undergoes decomposition, and mingles with the other materials of their composition.

When I tell you that if you take the mud thus deposited and wash out the sand, so as to leave the mud pure, it has been found to contain sometimes 25 per cent of the remains of these animals, you will see how much this animal substance must contribute to the chemical com-

binations, which compose the soil, and to its fertility. It is interesting to know, from what causes, this richness comes, if you would judge correctly of the relative fertility of these soils, at the mouths of rivers and further up beyond the reach of salt water. As far as the salt water reaches, there the remains of animals, are found in the mud of rivers, and the more of them as you approach the salt water. But, gentlemen, these animals are also to be found in our *soils*, and though it has not been proved by investigation directly, that they are capable of injuring the roots of plants, yet it is not improbable that they do interfere with the profits of the farmer, and materially affect the growth of plants. In some geological formations, which you see represented on the map of the State of New-York, and of the United States, the remains of animals of this infusorial kind, are found in great numbers, and it is remarkable that in many of these formations, many of which are marine rocks, their remains are precisely of the same kind as those which are now found in the sea that washes your shores. I take great pleasure in alluding to this, because the researches into the nature of these animals, by Prof. Bailey, of the West point Institution, have contributed to shed new light on this subject, and have reflected high credit on Prof. Bailey, and the country to which he belongs.

I have been obliged to hurry rapidly over these subjects—but you see from what I have said, how wide they are ; and you will see, as we proceed, that the general inferences to be drawn from them, are important.

If a science takes hold of the plough handles and points it deeper into the earth, in order that the roots of plants may reach a lower depth, for roots will grow deeper, if you will let them, and the deeper they go, the more robust the plant and the more profit to the farmer ; if it accompanies us to the field and teaches us to put trees and plants at proper distances from each other, that they may have the benefit of fresh air, and thus bring new food in reach of their leaves—and how much of this sort of sustenance, they are able to take in—if it tells you of the causes of the fertility of mud banks and sea-islands, and where you are to look for soil of the richest quantity, and how you should select with reference to that point—if it follows you into your barns and tells you how to treat your cattle—and what is the effect of certain treatment—to what diseases cattle are subject, and how they are to be prevented and cured—and if it goes with you into the fields, and instructs you in the nature of the insects that attack your crops, and as to the means of destroying them; I put it to you to say, whether if science can do all this, it is to be considered either as useless or unprofitable to the farmer.

Prof. J. closed his lecture by adverting to the feeling of contempt with which ignorant persons engaged in the humbler pursuits of life, and who are indebted to chemical science for success therein, regard a knowledge of such science, instancing as an illustration, the case of a washerwoman who used the soap which chemistry had taught the mode of manufacturing, who would tell you, if informed that without the aid of Chemistry she could do nothing—that she knew nothing of chemistry—that she washed her clothes as others had done before her, who knew nothing of Chemistry, and that she cared nothing about it. He remarked that this was true of a numerous class of farmers, in the old country, who performed all their operations, as it were, at second hand, which they had learned perhaps only from practical men; and if one of these men were told that science had done much to improve his art, and might do more, and he should reply that he was a plain practical farmer, knowing nothing, and caring nothing about science; gentlemen, he is an agricultural washerwoman, [laughter.] We have a few in England; I do not know, I hope at least, that there are none of them here.

LECTURE FOURTH.

THE RELATIONS OF METEOROLOGY TO PRACTICAL AGRICULTURE.

GENTLEMEN: The lecture this evening is on the relations of *Meteorology* to *Practical Agriculture*.

You recollect that when treating of the relations of Geology to practical agriculture, I explained how it is that the rocks that form the solid crust of the globe, gradually decomposed and crumbled down, so as to form the materials that cover the surface, and from what hard materials the soil is produced. I explained that the causes of this disintegration of the rocks, were ordinarily to be found in meteorological agencies; that is, the warmth of the sun, the influence of rains and peculiar kinds of atmospheric action, combined with the severity of frosts and the alternations of cold and heat. From this, you will perceive that the study of meteorology is closely connected with the origin of the soils themselves, and with those geological phenomena which I presented as of great importance to the agricultural inquirer. But into these branches of the subject I do not propose to enter this evening with minuteness. I will merely observe in passing, that the study of Meteorology in connection with this branch of science, is highly important. But I propose to treat more particularly of what is called climate and of its influences on the growth of crops on various kinds of soil.

The main elements of climate are the temperature of the air, and of the soil itself; the quantity of rain that falls, and the character of the prevailing winds, and under these three several divisions are comprehended, minor branches of knowledge, each of which is of great consequence, and to some of which I will draw your attention.

You will recollect that I explained to you, in a former lecture, what is called mean temperature; that is the temperature of a whole day, month or year, taken on an average. To explain this matter fully, would require a map of the globe, which I have not now. I have only a map of England, which will serve, perhaps, to illustrate the subject sufficiently, as it is sufficiently extensive to show the different degrees of temperature in different latitudes, and though these differences are not as striking as they would be on a map of this country, yet they are

enough so, to show the important influence which temperature has upon the growth of plants, and how decisive they are of results. If you have a map of the whole globe, and the ascertained mean temperatures at every place on its surface, you will find that on a given latitude, there are a certain number of places, where the mean temperature approaches nearly an equality; that is, that if you add the cold temperature of winter with the high temperature of summer, throughout this latitude, you get the average mean temperature of that latitude. Suppose there are fifty different points on the same latitude all round the globe, where the mean temperature has been ascertained, and you draw a line connecting these places with each other; then take another latitude, and draw a similar line connecting similar points, indicating another degree of mean temperature, and so on, you will then have a series of lines, indicating the mean temperatures of different latitudes in all the places through which these lines pass. These are called isothermal lines, a word compounded of two Greek words, meaning equal temperature.

You will recollect that I told you in a previous lecture, that where the mean temperature was 70 or 72 degrees, the sugar plant thrived most luxuriantly, and yielded the largest returns at the least cost of labor. You see, then, that if you follow these lines around the globe, whenever you find the temperature as high as 72, you know that there you are to look for the places where the sugar cane thrives best, and thus knowing what crops grow best on a certain spot, having a certain mean temperature, that other circumstances being the same, the same crops will flourish elsewhere, under the same temperature.

This is an extensive subject, and a great many observations must necessarily be made, in all parts of the globe, to determine these isothermal lines, and I have elements enough before me to occupy the whole evening, without fatiguing you, were I to use them in illustrating the interesting points which these lines present.

If you fix on two or more places, where from observation, you have the temperature of the summer months, and another set of observations of the temperature of the winter months, and another of the summer and winter months, and then connect all the places of which the mean summer temperature is the same, then you will have a line varying from the other lines, and thus you may draw a new set of lines. These are called isothermal lines; that is, lines indicating equal summer temperature; and so you may draw lines indicating an equal winter temperature, and thus you will have three sets of lines; one indicating mean temperature, all the year; another the summer, and another, the winter temperature. Now you will perceive the ap-

plication of these observations, when I tell you that there are places where the mean temperature of the whole year is the same, and yet the temperature of the winter and of the summer, is very different; for instance, where the summer is very hot, and the winter very cold; yet the mean temperature of both, will be 60, the heat of summer in the one, compensating for the cold of winter; and in the other, the reverse. Of course the climate of two such places, is very different.—The climate of America, is different from that of England; and the vegetable productions which grow naturally in each, vary accordingly. And yet the mean temperature of the two countries, is about the same, the difference being caused by the different mean temperatures of summer and winter in the two. Here then is another study. The study of these isothermal lines, or of the temperature of summer and winter in different places, and of the mean temperature of the year. So that the more we enter into this study, the more we perceive the bearing of this branch of science, on the practical capital of the farmer.

Another point. I have spoken thus far of the temperature of the air only. But this is not the only thing of interest to the farmer; the temperature of the soil itself is of equal consequence. This is a study into which philosophers, whose researches are confined to the crust of the globe, have entered largely. If you bore down into the earth to the depth of 60 feet, and let down a thermometer into the bore, you will find that in summer, the temperature at a certain depth, varies. It rises in summer, owing to the fact that the sun affects the temperature of the earth down to a certain depth, and so does the cold of winter. The thermometer, indeed, will never remain stationary, until you reach a certain depth—about 50 feet below the surface—there the thermometer remains stationary the year through: showing that the summer and winter do affect the temperature of the earth, to the depth of 50 feet. The depth at which the thermometer remains stationary, indicates a certain degree of temperature of climate. If at Albany, for instance, it were fixed at 50 feet, it would be fixed at that depth, one hundred years hence, as no doubt it was one hundred years ago. These similar observations made all round the globe, enable you to connect those places, where the temperature of the earth is uniform, thus showing by a line, that they have the same uniform temperature at this depth.

Such observations have been made, but not so extensively as with reference to the temperature of the air. But as boring to such a depth, is an expensive operation, the observations have been, of course, limited. Such as have been made and connected by these lines around the globe, are called, when connected, iso-geo-thermal lines. But these observations are of no great interest to the farmer, but it does concern him to

know the temperature of the earth down to 3 or 4 feet below the surface. Such observations as these have been made, to some extent, but not so far as is desirable. The temperature of the first foot is of far more consequence than that at a greater depth, because the seed is put in at a shallow depth, and vegetates at that depth ; in the spring, and as the summer advances, the roots go down deeper and deeper.

When I tell you, that in such climates as this, the temperature rises to 100 degrees of Fahrenheit, 5 feet below the surface, and to 140 degrees half an inch below, it will excite, perhaps, some surprise. It certainly surprised me. Such of you as rear plants in gardens, or have read upon the subject, know something of the importance of bottom heat, for the purpose of forcing plants, which it is difficult to grow, or which it is desirable should grow luxuriantly. There are certain parts of the earth, where there is a natural heat from beneath, as in volcanic regions and from the sun—which heat causes a growth of great luxuriance. In the neighborhood of *Ætna* and *Vesuvius*, this bottom heat is most apparent, in the growth of plants. But of this, we, in these cold latitudes, see nothing.

In a subsequent lecture, I shall draw your attention to the effect of drainage upon the warmth of the soil. But you will see, from what I have said, the great importance of a certain degree of warmth in the soil where the plant is sown.

From experiments made one year, in this neighborhood—I know nothing of them, but I speak from the representations of others—upon Indian corn, which you know, often rots when put into the soil, it was found that when the temperature of the earth was but 45 in the spring, the seed all rotted ; but when planted, when the temperature was about 60, it vegetated. These facts show the great importance of knowing, first of all, that the temperature of the soil has a close relation to the operations of the farmer and to the profit of his industry; and next that the study of the temperature of the earth is of great consequence in developing the various conditions of the soil, which are necessary to profitable farming ; thirdly, that if any means, within the compass of art can be found, which will make the soil warmer than it otherwise would be, and which shall impart that warmth early in the spring, we shall have arrived at a method of controlling nature, as it were, which must lead to important results. Drainage is one of these modes, and has been found of great practical utility in making the soil warmer at all seasons, and of particular utility in making the soil ready for sowing in the spring, as it enables the farmer to avoid losses by the seed rotting. It is specially important, in my country, where scarcely half the wheat sown, vegetates.

I pass on to another subject, or rather to another branch of this subject. I speak of the sun's rays, and of the warmth that the air and the earth derive from the sun. The rays of the sun, by the interposition of an instrument called a prism, can be decomposed, and separated into several different colored rays. This is familiar to all. But other things have been ascertained, which are not so well known. It has been found that, besides the fact that the sun's rays consist of light of different colors, which, when mixed, form a white color, that they contain three different kinds of rays. There is a ray of light—that you know; there is a ray of heat, but the rays of heat are not the rays of light. On the contrary, we can separate the one from the other. The sunbeam contains, also, a chemical ray; so that, though colorless, it consists of three different kinds of existences—not matter, but agencies—the one being heat, another light, and the third a chemical agent. I shall go into this subject further, in a subsequent lecture, when I will show you how plants grow. At present, I shall merely glance at it. When a plant takes root in the ground, chemical changes go on; the more numerous the parts of the plant, growing at the same time, the more numerous these chemical changes. These changes are produced by the agency of the chemical element of the sunbeam. Thus, when the plant is beginning to approach maturity, and to ripen its seeds, then it requires the aid of heat. The warmth of the sun is necessary to ripen the grain.

Professor J. here pointed to a diagram exhibiting the colors of the different rays; the blue indicating the chemical ray, the yellow the ray of light, and the red the heating ray. But, said he, the point of consequence to the farmer, or at least the one of importance as showing the relations of the science of light to the art of Agriculture, is this, that these three agencies exist in different proportions in the sunbeam, in the spring, summer, and autumn. The blue, or chemical ray, is greater in the spring; the light greater in the summer. The chemical ray is less in autumn, and then the heating ray predominates. It is enough for me to state here the results of investigation, as represented by these different colors and their relative lengths, and to say that, by means which it is unnecessary to state, the proportion of these different agencies in the sunbeam vary in different seasons of the year, in order that the growing plant may arrive at maturity, and thus be enabled to perform the functions necessary to its healthy growth. But I cannot dwell upon this further than to say that here is a most interesting subject opened to us, which promises much interest, as further developments are made, because it has not only been ascertained that

these agents exist in different proportions in the sunbeam in different seasons of the year, but the experiments of Dr. Draper, of New-York, indicate very clearly that the proportion of these agents vary in different latitudes and climates. This is in perfect consistency with what I have stated, that the wants of plants are different in different seasons; and it may well be inferred, therefore, that these results are founded in truth. Thus, you see that this very interesting branch of study is also of great importance, and must have a close relation to the operations of the farmer.

But you will be interested while I draw your attention for a moment to another fact. You know the different changes which take place in the plant, in its progress to maturity, from the flower to the seed. It is known, that generally the flower of a plant has a higher temperature than the other parts of it. This is generally the case. It has been ascertained also that the darker colored flowers absorb the heat of the sun's ray, more than those of a light color; hence it is very probable that the colors of the flowers of plants, are connected with the quantity of heat which the flower requires to perform its functions, and that in ripening the grain, the color of the flower is adapted to absorb from the sun's rays precisely the degree of heat which is necessary to perform its functions.

Another point: the influence of light on a clear bright day, is different from that on a dark day. When the grain begins to fill, a cloudy day is better for it than a bright one—that is, when the sun is obscured and the temperature not very low. The number of clear days and cloudy days in a country, is one element of its climate, and one of those which tell on the rapidity with which crops grow, with which certain profitable crops can advance, and on the period of the year at which they will ripen. Indian corn and buckwheat, for instance, are both liable to be touched by early frosts, and if the character of the year be such as to enable these crops to come early to maturity, they escape the danger of these early frosts, according to the prevalence of sunny days, and the absence of cloudy weather. I need not dwell on the subject of frosts, for all know their effects in spring and fall, and that to the gardener, as well as the farmer, and to all engaged in husbandry, these are matters of great importance.

Another circumstance of climate, connected with low temperature, is the relative duration of the different seasons, especially of winter and summer, as representing the whole year. The transition from summer to winter, and *vice versa*, is very sudden at the north, so that they have only summer and winter, so to speak. The relative duration of sum-

mer and winter, has an important bearing on the rural economy, which the farmer should adopt, if he would derive profit from his labors. Where the winter is long, the farmer must lay up winter food for his cattle, to sustain them, when they cannot be turned out. Here, you have six months, during which you must provide food for your cattle. In New Brunswick, the average duration of winter is $6\frac{1}{2}$ months.

Another way in which winter operates, has reference to the period in which out-door labor may be performed. In the spring, he must sow early, that in autumn his crop may escape the early frost; but if the period which intervenes between the passing off of the snow and the time for sowing is short, it is obvious that the farmer must not only plough early, but must do it very rapidly, and the shorter the time, the greater the force required to do it. Here, therefore, is a serious drawback on the profits of the farmer, and one of great interest to him. In connection with this point, it is of great interest to know how far the winters of different places differ.

One curious circumstance, perhaps, you would not anticipate, is this: The average length of winter at Frederickton, New-Brunswick, which exceeds yours by some 25 days, does not appear to interfere with the produce of the land in the more northern climate. In the northern climate, vegetation grows more rapidly in spring. It is a curious fact, that on examining the average products of New-Brunswick, New-York and Ohio, the average produce of New-Brunswick is found to be greater than that of New-York or Ohio, though the summer is longer in both these States. Therefore, the farmer in these northern regions, has every encouragement to occupy every leisure moment in the preparation of his land, for the soil is not niggardly in its returns, though they must do more work in less time than in more southern countries.

Another fact; though the severe frosts last so long, they are not altogether without benefits; if the frost descends to the depth of three or four feet, as it does in the country between the St. Lawrence and the Bay of Fundy, the effect of warmth is such that it heaves up the ground, and renders it almost ready to sow wheat, as soon as the frost is out; and it is a fact which practical men tell me, that the depth of the frost actually aids in preparing the land for the crops, and makes the work of plowing easier. Thus we see that nature is sometimes far kinder to us than we to ourselves, and that while she is shutting up land, as it were, she is preparing it, the better for use when the summer sun shines; so much in regard to temperature.

I told you that the next element of consequence, was the quantity of rain that falls. On a former occasion, I described to you the condition of various parts of the earth, where no rains ever fall. In parts of Asia,

and Africa, no rain ever falls. Now the fall of rain, is a matter of interest. First, in regard to the quantity. Secondly, the time when it falls; and thirdly, in regard to the manner. First, as to quantity. From the observations made in different places, I cite a few statistics. In London, the quantity is 23 inches, that is to say, supposing all the rain that falls, is dammed in and measured. In Edinburgh, it is 24 inches; in Liverpool, 34 inches; in Manchester, 36 inches; in Keswick, a very wet place, 76 inches; in New-York, 42 inches; in Rochester, 39 inches; in Worcester, 39 inches; in Portland, Maine, 44 inches; in Savannah, 55 inches; in St. Domingo, 150 inches; in Bombay, 50 inches. In some parts of the world, I may state, as on the Runn of Kutch, in India, between June and September, 240 inches of rain falls, that is, during the rainy monsoons. You all know how important the quantity of rain is, to the growth of plants. Let me illustrate this, by reference to the statistics of my own island. On the west side of the island, you will have seen, that the quantity of rain that falls, is greater than on the eastern. At Edinburgh, it is 24 inches; at London, 23 and 24; but on the west side, at Liverpool, it is 34 inches; at Manchester, 36; at Keswick, 76. This is found to be universally the fact, that more rain falls on the west, than on the east side; and it is known, that the green crops, the potato and the turnip, which require more moisture, are more grown on the western, than on the eastern coast of England. The average of these crops, in the western part of the island, are nearly double the average of the same crops in the eastern part. Thus you see that the kind of husbandry depends upon the quantity of rain that falls. Where no rain falls, there is of course, barrenness, unless certain causes come in to supply the deficiency. Where rain falls periodically, as on the Runn of Kutch, there you have a season of growth, and a season of barrenness. Where rain falls in autumn, it often impedes the ripening of grain. In Iceland, where the temperature is high enough to ripen barley, the rain comes on in autumn, to prevent it. But there are circumstances, which, whatever the season at which the rain falls, modify the kind of husbandry, and render the soil capable of producing certain things, which naturally could not be grown. Suppose the rain to fall only in certain months; the consequence is, that evaporation, not being as great as the rain that falls, the land becomes saturated with water, and the consequences of this are well known.

But art can do something to make such lands capable of producing some crops which they otherwise could not, and that is, by drainage. An artificial mode of relieving land of surplus water, not carried off by evaporation, and which otherwise must remain and stagnate. Drainage

is of two kinds: one is for the removal of springs, the water that comes from the earth—the other for the removal of the surface water which falls from the clouds, and which cannot be evaporated. All know that stiff clay soils require such drainage. In our climate, all the clay soils can only be made productive beyond their natural capabilities, by drainage. But there are other soils of a light character, such as the loamy soils, approaching the character of gravel and sand, which have been found to be improved by a thorough drainage for the removal of the surface water. But drainage becomes more or less important, not merely with reference to the character of the soil, but to the quantity of rain that falls. Take, for instance, London and Edinburgh, New-York and Rochester. The quantity of rain that falls in these places, other things being equal, determines the degree of necessity for drainage. When I tell you that near Edinburgh, where the rain is only 24 inches, it is found that an expense of five, and even eight pounds an acre, for drainage only, is found to be profitable, in the removal of surface water, you will perceive that it is a matter well deserving the consideration of the practical man, who desires to improve his soil, whether this system of thorough drainage, could not be introduced with advantage in this country, where the rain that falls is more than in England. We find that in almost all soils, such expenditures are not only profitable, for the time being, but that it pays its own expense in a few years, and leaves the land permanently good. At Albany, you have 40 inches of rain, and in other places mentioned, you have much more, showing that in this State, at least, the land would be improved by this system of thorough drainage. One observation here. It would appear that the extreme heat of your summers ought to render drainage unnecessary, but when I tell you that among the places with which I have had communication, by letter and otherwise, are Jamaica, and Barbadoes, and Demarara, where the summers are as hot as yours are, and where the soils are often stiff clays, liable to be dried up by the heat of summer, and that in these places where I have recommended drainage, the results of the experiment have been that the land has been improved in productiveness, and has yielded far greater crops than similar land, not drained. You will see that the removal of water from stiff clays, by drainage, even in climates where the summers are hot, and are characterized by great drought, may be resorted to with advantage and profit, and that after all, the quantity of rain that falls is of more consequence than the heat of summer.

In connection with this point, let me draw your attention to another mode, by which wet and marshy lands can be benefited. It does not

properly come in here, but it will serve to show you what great results may be accomplished by human ingenuity, when intelligently directed. Prof. J. here pointed to the northern part of England, to the Humber and the Trent rivers, saying that through the Trent, the tide runs with great velocity, far up the river, carrying with it a very muddy water. From the Trent, a canal has been cut for many years, for the purpose of bringing this muddy water from the river into the interior of the country, and pouring it over the surface of the land. Thus said he, the water is let in upon the land, twice every day; as the tide retires, the mud is left, and in the course of six months, it sometimes leaves a depth of six inches or a foot of sea mud, the fertility of which is well known. The same process has been adopted on a smaller scale in different parts of the island, and so it has in New Brunswick.

Another way of reclaiming land has been put to use in Italy. There are celebrated tracts of country, famous for having been once marshes. But in Florence, in Tuscany, there occur the most remarkable. It is called the Val d'Arno, and it is said to have been the course of a river which once flowed through the valley into the Tiber. The current being sluggish, the valley was once an entire marsh. Various efforts have been made to drain it—but more recently a process has been adopted which is exceedingly beautiful. The whole valley was divided into square portions, considerably elevated at one end of the valley, and the water being made to flow from one of these square enclosures into another, so that the whole valley became gradually filled up, and is now converted into one of the most fertile regions known in Italy. The water flowing, in fact, in a different direction from what it did originally. Thus you see how by adapting your operations to circumstances, natural difficulties may be overcome and made conducive to health and profit.

Among other things connected with this subject, I may draw your attention to fogs and mists, which often cause great injury to the farmer. You are accustomed to consider our climate as more foggy and misty than yours; but if these numbers I have given you are true, we have less rain than you. Whether we have more fogs and mists at certain seasons, I do not know; on the Thames and in London, fogs are more frequent than in other parts of England; and probably the ideas of our climate, formed by strangers, are the result of impressions drawn from visiting London alone, and not other parts of England. But the way we remove fogs and mists, except in the neighborhood of London, is by the removal of their causes—by drainage. Not having it in our power to do as in many parts of Italy, we have been obliged to remove water by drainage, and by this means, over a large portion of our coun-

try, fogs and mists have disappeared. In Lancashire, there was a lake, which was celebrated for its mists and for the agues which prevailed in the neighborhood. Every man nearly was affected by it, who lived within the range of its influence ; and so notorious had this become that the farmers in other and more favored localities, would never hire a servant who came from the borders of that lake ; but by drainage, the land about it has been rendered as fruitful and healthy as any of the neighboring lands. So on the Tweed, a rich tract of country, the same disease was prevalent to a great extent, until the system of drainage was introduced, not merely for the sake of increasing the crops, but to remove these causes of disease. But the crops were much greater after drainage, and the result was, that not only the profits of the farmer were increased, but the ague and complaints of the lungs almost ceased.

I have now explained how fogs and mists were caused, and how they were removed. I have explained to you how a cold and warm current of air meeting, form a mist ; but how is it with the air on the surface of the earth ? Whenever the surface is wet, it is continually cold. If I pour water on my hand, the evaporation of the water causes a perceptible sensation of cold. Now, the air sweeping over marshy portions of land, becomes cool, and deposits water in the form of mists, and thus the injurious effects are produced, not only upon health, but upon the crops, in the shape of mildew and rust. As to rust and mildew, they are owing to the prevalence of too much moisture in the air, in the shape of fogs and mists, and the remedy is drainage. But this is not uniformly the case, because fogs come sometimes from large bodies of water at a distance. In New-Brunswick it often overspreads the country, from the Bay of Fundy, settling on the damp lands, and even on the dry. At the head of the Bay of Fundy, I am told, that the prevalence of mists, combined with a very hot sun, produces very injurious effects on the crops. But it often happens that a farmer on one side of a road suffers from the negligence of his neighbor on the other side ; he perhaps drains his land, while his neighbor neglects his. Now, the farmer who understands the advantage of draining, could well afford to drain his neighbor's land at his own expense, as the fogs from the wet land in the neighborhood are often the cause of great injury to the crops on lands, which have themselves been thoroughly drained.

There are other topics connected with this subject, but I cannot touch upon them now ; but you will see from what I have already said, that in this subject of meteorology, are involved many different branches of study, every one of which might occupy the researches of one man for many years, and every one of which has a bearing on

practical Agriculture, and the profit of it. And though the farmer may not see the bearing of these researches immediately, yet results are always arrived at, which are capable of a direct and practical application to the farmer's art, and when the range of the sciences shall be still farther extended, we can then extract from them all a system of principles, by which a practical and sound system of Agriculture can be established.

LECTURE FIFTH.

(This Lecture was delivered at the annual meeting of the Society.)

THE RELATIONS OF CHEMISTRY TO THE SOIL AND ITS PRACTICAL IMPROVEMENT.

The Hon. John A. King, President of the State Agricultural Society, called to order, and introduced to the Society Prof. Johnston, who addressed the society as follows :

MR. CHAIRMAN AND GENTLEMEN: As there are present this evening a number of persons who were not in attendance at my former lectures, perhaps you will excuse me for mentioning, in order that the object of this course of lectures may be understood, that the purpose in view has been to present a general idea of the relations which science bears to practical Agriculture—not, of course entering into those details which the wide field presents—but dwelling only on those general aspects which hold a striking relation to this most important of all arts. Such of you as were at Syracuse, may recollect that I then mentioned that I might select illustrations, of the applications of science to Agriculture, and present them to you on the occasion of your annual meeting. As that address is now in your hands, you may readily ascertain how far this purpose has been carried out. The first of these lectures was on the relations of physical Geography to Agriculture; the second on the relations of Geology to Agriculture; the third on the relations of Botany and Zoology to Agriculture, and the last, on the relations of Meteorology to Agriculture. I may, perhaps, add to what I have said, that each of these lectures, being on a separate subject, is entire and complete in itself, and therefore contains in itself all the elements necessary to a comprehension of the general bearings of each subject to practical Agriculture. Thus this lecture, which has reference to the practical improvement of soils, will not draw on previous lectures.

Gentlemen, in drawing your attention to the relations which Geology bears to Agriculture, I pointed to this map of your own State and showed you the different kinds of rocks represented by different colors, of which the surface is composed, and I explained the process by which the va

rious kinds of soil were formed—that is, by the crumbling down of rocks, of different formations, and that these materials constituted the chief ingredient in all soils. By this crumbling down of the rock, a loose material is produced, which formed, I would say, a substratum, in which the seeds of plants might take root and vegetate. These plants coming to maturity and dying, and others succeeding them to mature and die, with the insects and animals which feed upon them, and the remains of all being mixed up with the rocks in a disintegrated state—these form what we call soil, on which the labor of man is expended and crops are grown. Hence the origin of soils is, first, the solid rock; and second, the remains of vegetables and animals, which, while they enrich the soil, also give to soils that variety of character which exists.

In considering the quality of soils, there is one point to which it is necessary to draw your attention—that is, to the chemical relations of soils. I formerly drew your attention, and now do so again, to the fact that if you take the same kind of matter, exactly, you may convert it, without changing its chemical composition, from one mechanical condition to another. Thus, this piece of plastic clay, which would be difficult to till, may be converted into the hard, solid brick, which, if pounded out by artificial means, or crumbled down by atmospheric action, becomes a soil very easily cultivated. This mechanical character of the soil very much controls the kind of plants that will naturally grow on it. On very light lands, rye, of all grains, grows best; and of all food for cattle, spurry grows best on light, sandy soil. In Europe, it is considered an exceedingly milk-producing food for the cow. On loamy and gravelly soils, you know, barley is a kind of grain that grows best; turnips and Indian corn also do well on such soils. In fact, barley could not grow on a stiff clay, such as I have exhibited here; but it would grow well on the brick that is made of it, pounded up, and forming a loose and open soil. But on heavy, clay lands, wheat, clover, and grass grow most luxuriantly; and I showed you, the other night, that a stiff clay soil, though it would not pay for cultivation, will pay well if devoted to pasturage.

These physical characters of soils are of great consequence; and whilst I shall show you that the chemical composition has much to do with their fertility, and that after a soil is exhausted, and the art of man is brought to restore it, success depends greatly on a knowledge of this chemical composition, yet, I shall show you that whilst a knowledge of chemistry is important, the physical or mechanical condition of the soil is not to be slighted, and indeed is the first thing to be re-

garded, and is, after all, considered more essential than that which we cannot see, and for the most part know nothing of.

I pass this over, and turn now to the chemical composition of soils. What does this piece of plastic clay contain, and what this hard brick? Both contain the same matter. In order to obtain that knowledge which shall be useful to us, as practical men, in tilling the soil, we must begin with some soil of known value and fertility, and which is known to produce good crops in ordinary seasons, and with ordinary treatment. When such a soil is taken—and there are many such here, particularly in the virgin soils of the West—we find it to possess a great variety of combinations. Before going further, I will repeat what I have said before, that all rocks consist of one or more of three kinds of matter—limestone, sandstone, and clay, or we have mixtures of them. This general view enables us to form an opinion of the physical character of soils at once. Sandstone gives a light, open soil; limestone, also; and clay, generally a stiff soil. Sometimes the clay is hardened, and the soil assumes a different character, like brick. But when you come to put these soils in the hands of the chemist—I mean these virgin, pure soils, which grow large crops, with little aid from labor—the chemist is not satisfied with the knowledge of the fact that they contain lime, sand, or clay, for he knows that clay itself is a complex substance, before he submits it to chemical analysis. He finds, as might be expected, that he extracts from soils these various substances, exhibited in this table :

Composition of soils of different fertility.

	Fertile with out manure.	Fertile with manure.	Barren.
Organic matter,	97	50	40
Silica,	648	833	778
Alumina,	57	51	91
Lime,	59	18	4
Magnesia,	8	8	1
Oxide of iron,	61	30	81
Oxide of manganese,	1	3	trace.
Potash,	2	trace.	"
Soda,	4	"	"
Chlorine,	2	"	"
Sulphuric acid,	2	1	"
Phosphoric acid,	4	2	"
Carbonic acid,	40	4	"
Loss,	15	0	5
	1000	1000	1000

But first of all, let me draw your attention to a fact. If I take a match and ignite it, and allow it to burn away, you will find that a small portion remains behind after the greater part is burnt away. The part that remains is the wood ash. This is the result if you burn any vegetable substance whatever, and as in soils there is both vegetable and animal matter, if you burn it, a portion of it is burned away; but that portion always leaves a quantity of ash. But this matter will be more fully explained at our next meeting. The part that burns away is called the organic part, or organic matter; and the part that is not burnt, consists first of silica, which means flint, and then alumina, that is, the substance which gives tenacity to the clay. If I dissolve clay in water, and into that pour hartshorn, it immediately becomes milky, and a white substance is precipitated, called alumina. It exists largely in clay, and is what gives its tenacity.

The soil also is found to contain lime, magnesia, oxide of iron, potash, soda, chlorine, which is a kind of gas, of a greenish color, having a peculiarly strong odor and very heavy, and in this respect distinguishable from common air; a taper will burn in it, but will give but little light; it burns red, smokes, and soon goes out; it is so heavy that it can be poured from one vessel to another. This gas possesses many properties, but it is quite enough to know at present, how to distinguish it from other gasses or air. It may strike you as curious, that this gas exists in the soil, and chiefly in the form of common salt; indeed, every ten pounds of salt, contains about six pounds of this gas. Sulphuric acid and phosphoric acid, also form parts of the soil. Let me draw your attention to the fact that if you ignite a lucifer match, it emits a peculiar odor; that is the odor of phosphorus. When the match is first lighted, you perceive a white smoke; that is phosphoric acid. Carbonic acid also exists in the soil, but I will not dwell upon that now, as I shall speak of it in my next lecture.

The soil, therefore, when chemically analysed, is found to contain many other substances, than sand, lime and clay, and enables us to enter into the minutest kind of reasoning, as to the functions of the soil, in relation to the plant, and how the soil is to be improved. It is of great consequence to understand this composition of soils, and any one who wishes to know how to manage the soil intelligently, should attend to many things besides the substances it contains. You will see by reference to this table, that 1000 parts of a given soil contain 648 parts of silica, 57 parts of alumina, and 59 of lime—that is to say, that though all these things are present in a fertile soil, they are not so, in the same proportions, but that they vary in a certain ratio, in the most fertile soils.

Another conclusion: we find that other substances exist in the very smallest quantity. I shall have occasion at our next meeting to show how important these substances are to the existence of vegetable and animal life. Though they exist in small proportions, yet that is not to be the measure of their value or necessity to the growth of plants. The importance of these substances is not measured by the numbers in this table, because their presence in small quantities is just as necessary, as that of those substances which exist in larger proportions. If I have the small finger and thumb, I have a hand that is not altogether useless; but to make a complete and useful member, I must have all—the smaller as well as the larger parts of the hand. The same parallel exists in regard to the soil. All the ingredients must be present, the smaller as well as the larger to make the soil—but though all these ingredients are necessary, and though every soil which grows good crops, either naturally or by art, must contain them all, I shall show you that it is not necessary that they should all be present in these precise proportions. It is enough to say now, that every fertile soil contains them all.

One step further: If I take specimens of several fertile soils, one from America, another from Asia, and another from Europe, and analyse all of them, I find every one of these ingredients in them; but no two of them contain any one of the substances present in all, in the same proportion. I exhibit here, (pointing to a diagram,) the composition of the soil on the plains of Athens. You will see that it contains 38 per cent of the carbonate of lime or nearly four-fifths of the entire soil. Here lime constitutes only 59 parts in 1000 of the soil. The plains of Athens are celebrated for their fertility—this, then is an illustration of the fact that a fertile soil, may contain all these things, yet that two, equally fertile may contain them in different proportions.

One step further: Soils of the same degree of fertility, may contain different proportions of these ingredients, but it may happen, that one of these substances is present in large quantity, and that may be injurious to the soil. Soda and chlorine form common salt. Those who have examined the soils on salt marshes on the borders of the sea, know that common salt abounds in those soils, and in such large quantities that crops cannot grow upon them. The soils reclaimed from the sea, as on the Bay of Fundy, are found to be loaded with salt, so that at first they do not produce even grass—the seeds do not come up—but after a time, the salt being washed out by the rains, the seeds grow. This illustration is in point, and shows how the presence of this substance in large quantities, instead of enriching the soil, makes it worthless. If I could draw your attention to many things that press upon

me, I might ask, why, in all fruitful soils, we find these things in small quantities, and why it has been so ordered by nature, that where saline matters existed once in large quantities, and contributed to your use and mine, that the rains from the heavens should be the means of carrying off these things, present in too large quantities, and the presence of which precluded the growth of crops which sustain human life?

One step further: There are soils, not of this fruitful character—some which will not grow crops at all, or not enough to pay the cost of tilling them. There are other soils again which, with ordinary treatment, grow good crops. We have soils which are fertile, others which are barren, and others again which, naturally fertile, require proper treatment to make them productive. In the little catechism which I have published, and which has been republished in this country, with an introduction by Professor Norton, you will find a tabular statement of the composition of these three kinds of soils.

There is a soil (pointing to the table, ante 212,) which lacks three things—soda, potash, and chlorine. You see, also, that here are three things of which a trace only could be found in a certain soil. If I were to ask you how you would make that soil chemically equal to that in the first column, where the three are present, you would say at once, put in the three things that are wanting, and thus make up the deficient numbers. That is common sense. To make the two soils chemically equal, you have only to add these things that are wanting, in the proper proportions. Now, manure adds these ingredients.

Here is another soil which is barren. You see here that no less than six substances are missing—half the whole number—potash, soda, chlorine, sulphuric, phosphoric, and carbonic acids. This is a large gap; and ordinary manuring will not make it grow good crops, as it would not restore the chemical agents present in other soils. You perceive also that a large proportion of the soil consists of oxide of iron—81 parts in 1,000. This illustrates the fact that certain things may be present in too large quantities. I could point you to many places in England where this is the case. It is a noxious substance, which creeps in under the soil, forming a hardpan, lying between the under and upper soil, and the roots of plants cannot penetrate it. If present in such quantities, it presents a great difficulty, because it is necessary to remove the excess. Where the soil is overcharged with salt, rains will wash it out; but this is not affected by them. Nature does much for us, however, by carrying it down below the surface, and thus points out the way which we must take to remove it, when necessary. Thus, the

barrenness of a soil may arise either from its not containing the proper substances, or from containing some of them in too large quantities.

What are the purposes served by the substance of the soil? I do not mean to enter fully into this matter to-night, for it would lead me into too wide a field; but you know a common purpose for which soils are necessary to the growth of plants. It is illustrated by putting a piece of wood into a piece of clay, it forms a basis in which the plant may anchor itself and maintain an upright position. That is an important function of soils, though it be only mechanical. If a plant, like barley, tends to go down into the earth, the soil must be open. So with other plants like wheat, which however, requires a stiffer soil. This is the first function of soils; a mechanical function entirely. But there are others; generally they feed the plant. This I shall illustrate particularly at our next meeting. But I will now call your attention to the fact that if you burn wood or other vegetable matter, the ash will remain, that is, the inorganic part. The part that burns is the organic part. The inorganic portion it is the function of the soil to supply.

Another function of the soil is, that it not only fixes and feeds, but carries in food to the plant. This flint will not dissolve in water, but if I take potash and reduce the flint to powder and put it in, I can dissolve it in the potash, and when dissolved it looks as clear as water; but it will contain the flint in solution. I will show you that by a mechanical contrivance of this sort, the plant actually acquires and contains a quantity of flint, and that that being insoluble in water, is by the agency of potash, carried up into the plant and left there. This potash makes the silica soluble. It serves as a car to carry in the silica to the plant, so that the substance of the soil not only serves to feed and root the plant, but there are things in the soil which carry into the plant those substances which otherwise they could not get, and leaves them there.

These are the principal functions of the soil. At our next meeting I will describe to you others, which will become more intelligible as I open up the composition of plants. But on this subject allow me one more observation. Take a fertile soil, however rich, and suppose it to grow crops for 30 or even 60 years; a time will come when it will not produce crops. Every farmer knows that, and he knows also how much the richness of the soil is abused. This is called exhaustion; and the tables before you illustrate what it means. Suppose a soil, having the composition of that in the first column, will grow crops without manure. Suppose one of the kind in the second, will grow crops with manure; but that they have become barren by a particular course of cropping,

and you know that where tobacco, cotton and sugar are cultivated, great tracts of country have become exhausted. There is also what is called general and special exhaustion. But this subject I shall advert to more particularly when I treat of the application of chemistry to manures. If I take away phosphoric acid and potash from a soil, it will produce no crop. If there was any process by which I could totally remove the phosphoric acid, the soil would be reduced to perfect barrenness. That would be special exhaustion. The loss could be repaired, as general exhaustion is, by the addition of manures; but the addition of substances that contain the one thing only, or some other thing, is the surest way to give the plants their supply. This subject of special exhaustion will be of use by and by, when I consider how soils may be chemically improved.

There are two modes of improving soils. I have spoken of the composition of soils. You see how they vary, and what differences there are in the qualities of soils, and what it is that constitutes equality of soil, and what the relation between these and the chemical composition of soils. But how are soils to be improved? There are two methods, the mechanical and the chemical. Of the mechanical method I shall now speak, and of the chemical in my last lecture. Among the various mechanical methods of improvement, there are three principal kinds. The first is deep ploughing; that in almost all cases is found to be important and profitable. In all countries where I have been, in all parts of Europe which I have visited, experience has shown that the soil generally is not ploughed to a great depth, 3, 4 or 5 inches is almost the maximum depth of exhaustion. It is very often the case, that persons exhaust land, until they can raise no more crops, and are then compelled to leave. The person who succeeds them, seeing the system of tillage that has been practised, instead of adopting the former system of shallow ploughing, goes down deeper and turns up a new soil altogether. Very likely in this new soil, are found accumulated the materials which the other soil once contained. The manure that has been put on and accumulated below, is turned up, and the new comer gets, perhaps, not only a good virgin soil, but much of the money that the old farmer has buried there. This is no hypothetical case. If it were, I would not state it, for speculation and hypothesis are good for nothing. In the neighborhood of Edinburgh, there are farmers of the greatest skill, and who make a great deal of money; and as a general rule, you may judge of the skill of a farmer by the number of sovereigns that he has pocketed at the end of the year; it is a very good test. One of these farmers, after hearing one of my lectures, in explanation of this simple

principle, told me, that though he lived so near Edinburgh, the thing had never occurred to him before, nor had he ever heard of it ; and he immediately went to work to carry out the principle, and by ploughing down, he had brought to the surface a fresh soil, and was then growing luxuriant crops, where he had thought the land entirely exhausted. Therefore, it is quite true, that in the under, or sub-soil, there accumulates many substances which have drained through from the upper soil, which make it full as rich as the upper soil once was, and that the farmer takes the cheapest steps to reclaim poor land, exhausted by severe cropping, who ploughs deep.

This must be sufficient to show the value of the sub-soil, when turned up and mixed with the upper. I need not dwell on this ; but I have this remark to make ; that it happens sometimes that various substances accumulate beneath, which are injurious to the plant, and in order that they may not injure the upper soil, it is not always advisable to bring them up. There are districts in my country, where the sub-soil is a white clay, which is so barren, that if brought up, it might destroy the upper soil, and therefore it is carefully avoided. This is the case in many parts of the world. It is quite proper not to do so ; but not an unfrequent resort with us, as a means of deepening the soil, where the sub-soil is impervious or noxious, is to cut it through, so that the water sinks, and as it sinks below the level of the soil, the rain falls, filling up all the pores in the soil to a certain point, which, with the fresh air, effects a chemical action on these substances, changes them chemically, and gives them either a nourishing quality, or modifies the sub-soil, so that when brought up, it will not be injurious or noxious to plants.

This is the object of sub-soil ploughing ; this is common in England, after draining in stiff clay soils. But the practice is also adopted where the land has been long drained. In Scotland, the farmers plough from 7 to 20 inches deep, and experience has shown that lands thus treated, not only retain every thing put on them in the form of manure, but are capable of growing crops for a longer time without exhaustion, than if they did not plough so deep.

Another mode, besides deep ploughing and sub-soiling, is called thorough drainage. I have spoken of thorough drainage, as applied to large areas ; also of the drainage for the removal of springs. The drainage of lakes is going on in Sweden on a large scale, and that of springs in Scotland ; but thorough drainage is only now begun, although probably thirty millions of money have been already expended in it.

There are several questions in regard to drainage which are important. What are the effects of drainage on land, and how these effects are brought about? How does this system of drainage affect the profits of the farmer, and in what way does drainage pay him? The first effect of drainage—for I cannot dwell upon them, but must put them down here succinctly—is to carry off all the stagnant or surface water; 2d, it relieves land of water where it accumulates below, by the filtration of the rain through the surface; 3d, it causes the rains, instead of running over and washing the land, to descend where it falls, and this is the perfection of thorough drainage; 4th, as the rain sinks into the soil, it carries with it a continual supply of fresh air, and thus administers new doses of air to the substance of the soil; 5th, it makes stiff soils more crumbling, so that this kind of soil, instead of being hard to work after drainage, requires but half the force to plow it; 6th, it makes the soil warmer. You remember that I told you, that evaporation cools the surface; of course, if the surplus water is carried off by drainage, the soil is warmer. Then it also enables the farmer to proceed to till his land much sooner after the rains fall, and thus get ahead of others who do not drain their lands. So in the spring and autumn, in the open weather, he who drains his land has great advantage. And there is another advantage; it benefits his neighbor as well as himself, keeping the mists and fogs of his own land from that of his neighbor, while the man who neglects this, injures his neighbor by the converse process. Another point to which I have alluded, and at which I will glance now, is that by this means, you compel nature to do the artificial work of taking out from the soil what is injurious to it, much more cheaply than it could otherwise be done. I have spoken of the importance of the healthiness of a climate. Among the means of improving lands, this of drainage has been attended with one remarkable result, in contributing to human happiness. It happens that drainage, while it has improved the soil, has been the means of improving the health of large districts, a result which every benevolent man must contemplate with high satisfaction. Drainage is attended not only with these good effects, but it gives the farmer larger, surer and more valuable crops. Land that would once only grow oats, has in this way been made to grow wheat. Crops that were uncertain, have been made certain, and the product doubled in quantity.

On what land does it do this? on wet lands, no doubt; but when I tell you that it does so not only on wet lands, but on lands liable to be burnt up with the sun in summer, it may excite surprise. I have a suggestion to make in regard to lands thus liable to be burnt up; but

of course, in making the suggestion, I do not intend that you shall go immediately to do it on a large scale, but that you should try the experiment on a small scale. But it is a fact, that on such land as I have described, thorough drainage has been found the most beneficial of all methods of improvement. In this neighborhood, you have sandy plains, and you have other stiff clay land. Now in summer, the sandy land bears the extreme heat, better than loam, and the loam better than clay; that is the soil which is most open, is least acted on by the sun. This is the case in the lands on the plains of Athens, of which I have spoken, which is liable to be burnt up by the sun.

Now if we consider the several causes by which this drought is produced, and how drainage affects it; you will see on what this experiment is founded. If the soil is merely burnt up by drought, and you suppose the roots to descend only to the depth of about 3 inches, it is obvious that the heat of summer dries up the land to the roots. But if by drainage, you open up the soil three feet deep, so that the rain, instead of flowing off the surface, descends through the soil, thus made pervious to it, the roots will grow deeper, and while the upper surface is dry, the drought does not reach the roots, which are thus enabled to live longer than they otherwise would. But there is another singular circumstance, with reference to soils that contain saline matter; potash is saline matter. The water with which it is saturated, comes to the surface, and evaporates, and this substance which is held in solution, is left on the surface, and kills the soil. Prof. J. here stated that he had sent him a specimen of the soil on the plains of Athens, for his examination and advice. On these plains, the grass grows luxuriantly in the spring; but as the sun grows more scorching, it gradually withers and dies. Prof. J. said that knowing the character of the rocks in that region, and that the sudden check to vegetation, was the results of the salt held in solution in the soil, and left upon the surface by evaporation the remedy was simple and easy; and that was drainage and ploughing. So that when the rain brought down the salt from the heights, it would also, run away with it, and not remain in the soil. Thus, you see, that the practice of draining, has been found to succeed, where it might have been least expected; and that it is an experiment well worth trying. I am sorry to detain you so long, but you will excuse me if I occupy a few moments, in answering the question, will drainage do in New-York; will it pay? I do not speak of this or that county, for I believe a discussion of this question, has already taken place, and that a great deal is to be found on the subject, in your volumes of Transactions; it is a discussion highly creditable in itself,

and from which I infer that you have confidence that it can be applied with profit, to certain parts of your State ; but some general considerations, may be of use. The quantity of rain that falls, determines the quantity that remains. The quantity in New-York, is much greater than in Great Britain ; yet we find in Great Britain, that it is not only necessary, but profitable. Now, the first question is, as to the quantity of rain that falls. Without any other data, I should say, that the quantity here, renders it probable, that drainage would do here. Knowing as I do, the profit of drainage, where there are but 24 inches of rain, I infer that where there are 40 inches, thorough drainage must also be profitable.

The way in which rain falls, is also important, and how many rainy days there are in a year. I did not anticipate that I should be drawn into this point, and cannot tell the number of rainy days in New Brunswick. During four months, spent among the practical agriculturists there, and after a thorough canvassing of the whole subject, I am satisfied, that thorough drainage, though expensive, can be safely recommended. In St. Johns, where it rains most, there are 74 rainy days in a year, In New-York, 111 ; in Rochester, 115. Here is another argument which strengthens the probability, that thorough drainage, might be resorted to with profit. I do not recommend it, nor do I want you to adopt my opinions, because I state them here. It was my duty to go into every county in England and Scotland, with a view to this subject. I conversed with the most experienced, practical men, in whose way I was thrown. The results are what I now tell you ; that drainage has been found effectual, in a country, where they have less rain than you ; where the soil is not stronger, or heavier than yours, and where the number of rainy days is not greater than at the places I have mentioned in your State. This, being so, whatever opinions you or I may entertain, the inference is irresistible, that the system may be tried with eminent advantage to the practical farmer ; and I would say that there is a probability, that thorough drainage may be the means of gradually improving your soils. I think it is worth while seriously to consider, whether you may not turn it to your own individual advantage, and thus contribute to the wealth of all.

LECTURE SIXTH.

RELATIONS OF CHEMICAL PHYSIOLOGY TO THE PLANT, AND THE MODES OF PROMOTING ITS GROWTH.

GENTLEMEN: There is one aspect in which the art of farming seems exceedingly simple. If you look at the procedure of one of those who cultivates the rich land of the Genesee valley, which is a rich clay mixed up with a calcareous gravel, you see the routine which he pursues in the alternation of his crops, and you observe that he pursues this course regularly every third year, and you may naturally infer that this is a simple art, requiring no mental exertion to carry on all its details. It is because this art appears so simple, that farmers themselves are unwilling to believe that there are any difficulties connected with it, that it has been generally supposed that very little knowledge is necessary to practice such an art; that it needs very little intellect or intelligence, and that if a man is fit for nothing else he has brains enough for this. Besides the obvious effect which this idea has upon the agricultural community itself, it has its effect also in lowering the character of the agricultural body in the estimation of the other professions. Now, if the agricultural body has reasons to complain of the estimation in which they are held in other quarters—and it prevails among us and every where—it appears to me that these persons themselves, that is the class of agriculturists who refuse to believe that there is any difficulty in this art, such as I have described, are themselves to blame for a state of things of which they complain. Those are really the friends of the agriculturist who show that this department of art can be made more certain in its results and more lucrative by the application to it of the various branches of natural knowledge, and that he is indeed the friend of the farmer who seeks to bring to bear upon it the results of scientific research, and to show the world that there is really something complicated in this apparently simple art.

I have been led to these remarks in consequence of having reached that stage in my progress which brings this most prominently in view;

that is, the relations of the soil to the science of Chemistry. You will recollect I showed you at our last meeting, that the soil is a complicated material, containing a great many substances, in different proportions, and on which proportions the quality of the soil depends. You will recollect that I showed you that the result of chemical research was the development of the fact that all fertile soils contained a certain number of certain things; and now I come to show you that all fertile soils do and must contain them, and that if certain of these things are wanting no soil can be fertile. To show the necessity of this I must bring under your notice the composition of the plant.

I explained to you at our last meeting, that if I take a vegetable substance and burn it nearly the whole of it burns away, leaving but a small quantity. I advert to this to show you that the same thing is true of the soil—as part of the soil burns away, and a part of every plant—but a certain quantity of each is left behind. Both contain a certain quantity of combustible and incombustible matter. In both, the first is organic, the second inorganic, or mineral matter. But they differ in this, that the part of the soil that burns away is very small compared with the whole mass, while in a plant the converse is the case; the largest portion of the plant burns away; so much greater is the combustible portion of it. [Prof. J. here pointed to a table showing the different quantities of ash left after burning different vegetable substances, wood, wheat, straw, hay, tobacco, &c.] Thus you perceive, said he, that in the case of the plant, first, the quantity of mineral or incombustible matter is less than in the soil, and second, that the quantity of combustible or organic matter is greater. Now, as the plant consists so largely of combustible matter, in order that we may know something of it, I must make you acquainted with some substances of which I have not yet spoken, as it will be necessary to illustrate not only what I have to say to-night, but at our next meeting. The part of a plant that burns away contains six different things, in different proportions—one or two of them in large proportions. This, [holding up a piece of it,] is common wood charcoal. If wood is ignited and closed from the access of air, it becomes charcoal. It contains all the mineral or incombustible matter of the plant. This charcoal, therefore, is a material representation of carbon. There are various forms of carbon, the diamond is one. But carbon is one of four or five other substances which constitute the combustible or organic portion of plants, and forms far the largest portion of it. Another substance is oxygen; a third hydrogen; a fourth nitrogen; a fifth sulphur; a sixth phosphorus.

Take any one plant, and the part that burns away contains these six different elements; but there are certain plants that do not contain all

of them. Oxygen, hydrogen, and nitrogen are three different kinds of air. Here are three bottles containing these different kinds of air. There is no apparent difference in point of color, nor have they any smell; you cannot distinguish them by these senses. But a very simple implement enables us to do so. This little taper serves the purpose of a new sense to us. I do not know which of these contains hydrogen, which oxygen, or which nitrogen; but this lighted taper will soon tell me.

Prof. J. here put the taper into the bottle containing nitrogen, and it was extinguished; he then re-lighted it, and put it into another, that containing oxygen, and it burned brightly; next, he put it into the third containing hydrogen, and there was a slight explosion, which put out the taper, leaving, however, the snuff, which ignited again, when it was withdrawn—the gas itself burning—and which ignited also when placed in the oxygen. This, then, said he, enables me to distinguish these three gases. This, in which the taper kindles and burns brightly and re-kindles, is oxygen; this, which takes fire itself, is hydrogen; this, which extinguishes the taper, is nitrogen. These three substances, hydrogen, oxygen and nitrogen exist in plants in different proportions, not in the shape of air, but in a solid form. We cannot imitate it; but they do assume this form naturally. Sulphur, you know exists in small quantities in plants, and phosphorus in a still smaller quantity. Now, these substances compose the organic part of plants, or that part which burns away. But where does the plant get these things of which it consists so largely? the carbon comes partly from the air, and partly from the soil; oxygen partly from the air and soil; hydrogen mostly from the soil; nitrogen altogether from the soil; sulphur and phosphorus, altogether from the soil. Oxygen and hydrogen compose water, and the plant gets them either from the rain, or from the water in the soil; carbon it gets partly from the air and partly from the soil. Now that you may understand how it is that plants derive these things from the air and soil, I must make you acquainted with another substance.

If I take a piece of limestone, reduce it to powder, put it into a vessel, pour on it first a little water, and then an acid, as nitric acid, it will boil up, or effervesce. This boiling up or effervescence is produced by the evolution of a kind of air which produces these bubbles. In this kind of air, the taper will be extinguished. It therefore corresponds in this particular with the gas called nitrogen, in one of these bottles. How are we to distinguish between these two gases? It is in this way: If I undertake to pour the nitrogen into this glass, I cannot do it; if I undertake to pour it on this candle, it has no effect upon it; but if I take the gas which produces this effervescence and pour it into the glass, I

can fill it, and though the glass appears to be empty, it will be found to be full of it, for if I put the taper into it, the blaze will be immediately extinguished. There is, therefore, this marked difference between the two gases: the one, the carbon, can be poured out into another vessel, because it is heavier than common air; but the nitrogen which is lighter, cannot be poured out; but it will rise. Hence the extinguishment of the taper is no test of the presence of carbonic acid or nitrogen; but they are distinguished altogether by their comparative weight. Common air is composed of 79 parts of nitrogen to 21 parts of oxygen, or nearly—carbonic acid constituting about 4-100 of it. This small quantity of carbonic acid exists in the air, and from this small quantity, plants derive all the carbonic acid which they get from the air.

How do they take it in? I showed you in a former lecture, that the under surface of the leaves of plants is covered with an immense number of minute pores, and that these pores vary according to the circumstances under which the plants live. They draw in through these pores, carbonic acid during the day, but not during the night. The very great number of leaves and surfaces thus presented to the air, enables the plant to draw from it the minute portion of carbonic acid necessary to its growth. This is one of the wonderful things, of which nature is full. You cannot but be astonished to find, that this never ceasing operation is going forward, and that the countless leaves of plants, which seem to us as intended merely for the ornament of trees, and to gratify the eye, by their perpetual motion, as the winds pass through them, are actually necessary to enable the plants to extract from the air, or to drink in the element so necessary to their growth and maturity.

I shall, at the next meeting, draw your attention to the substances existing in plants; that is to say, I shall show you that wood contains these elementary substances—carbon, oxygen, hydrogen and nitrogen—but that it does not contain them in the states in which I have exhibited them here, but in a different form, and I shall also show you that the plant consists of other substances, which are necessary to its existence as such. For instance, this piece of wood, (holding up a rod) consists of what we call, woody fibre, mostly. The stalk or straw of wheat, and grain, contains more than one kind of matter; so the seeds of plants, such as linseed, contain oil, among other things; so that we have all these things, growing in plants, in the wood, in the seeds, &c.

At the next meeting, I shall again call your attention to the functions of the leaf, and the manner in which the leaf acquires carbon from the

atmosphere, in order to explain the functions of animal life, and to show how these functions are related. I cannot do this now, because I must introduce new names and things, and because the subject comes in more strictly in connection with the next lecture. But I may make one observation here in relation to these substances, nitrogen, carbon, derived from carbonic acid, oxygen and hydrogen, which compose water; that nitrogen is obtained from the soil in various forms, and that that is one form in which it is taken in by plants, but not so universally as some have supposed. There is one form in which nitrogen exists, and that is in ammonia or common hartshorn. The nitrogen, which is necessary to the growth of plants, is often taken in, in this form, though not universally; and though it exists in plants, in small quantities, yet it is of the greatest possible consequence to the existence of human and animal life. Thus much of the organic parts of plants.

I pass on to the inorganic parts of plants; and here I shall show you the necessity of those mineral substances of which I spoke at our last meeting. If you take the ash of wood, or of any plant, and submit it to the same chemical examination to which I submitted that part of the soil remaining after being burnt, you will find what the chemist tells you, that this ash consists, not of one or two substances, but of eight or ten. It will be found that the soil and the plant contain the same substances; the only one not in the plant being alumina. What is the function of alumina in the soil? Its mechanical function is to anchor the plant. Tenacity is necessary for this purpose. Some plants grow in mere sand, but the great majority of them require a certain degree of tenacity in the soil, which is obtained by mixing silica with clay. This alumina being clay, explains why it is that it is not in the plant, but only in the soil. It does not enter into the plant but gives tenacity to the soil, which is necessary to retain the plant. Take any plant, and it will be found to contain this ash, and this ash you will find contains all these substances, some in larger, some in smaller quantities. To show the composition of the ash of different plants, Prof. J. referred to the tables exhibiting the composition of the ash and straw of different plants.

Composition of the ash from grain and root crops, and from the straw and husks.

Per centage of.	Wheat.	Straw of Wheat.	Oats with- out husk.	Straw of o's.	Husk of Oats.	Bar- ley.	Straw of barley.	Rye.	Straw of rye.	Field beans.	Straw of beans.	Peas.	Straw of peas.	Turnips	Pota- toes.
Potash,	23.72	12.44	26.18	19.14	8.13	13.64	6.31	22.08	17.36	33.56	53.08	36.05	4.73	39.82	55.75
Soda,	9.05	0.16	.....	9.69	.....	8.14	0.61	11.67	0.31	10.60	1.60	7.42	.....	10.86	1.86
Lime,	2.81	6.70	5.95	8.07	3.15	2.62	9.53	4.93	9.06	5.77	19.99	5.29	54.91	12.75	2.07
Magnesia,	12.03	3.82	9.95	3.78	1.09	7.46	3.22	10.35	2.41	7.99	6.69	8.46	6.88	4.68	5.28
Oxide of iron, ...	0.67	1.30	0.40	1.83	1.33	1.48	0.83	1.36	1.36	0.56	0.22	0.99	0.40	0.89	0.52
Oxide manganese, .....	.....	.....	.....	.....	0.61	.....	.....	.....	.....	.....	0.16	.....	0.15	.....	.....
Phosphoric acid,	49.81	3.07	43.84	2.60	1.54	38.93	3.08	49.55	3.82	37.57	7.24	33.29	4.83	6.69	12.57
Sulphuric acid,	0.24	5.82	10.45	3.25	6.46	0.10	1.63	0.98	0.83	1.00	1.09	4.36	6.77	13.15	13.65
Chlorine, .....	.....	1.09	0.26	3.25	0.73	0.04	0.97	.....	0.46	0.73	2.56	.....	0.09	3.68	4.27
Chlor'e of sodium .....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3.13	.....	.....	.....
Alumina, .....	.....	.....	0.06	.....	.....	0.21	1.39	.....	.....	.....	0.32	.....	1.21	.....	.....
Silica,	1.17	65.38	2.67	48.42	76.16	27.10	70.68	0.43	64.50	1.15	7.05	0.51	20.03	7.05	4.23
	99.50	99.78	99.76	100.00	99.20	99.72	98.15	101.35	100.11	98.93	100.00	100.00	100.00	99.37	100.20

There you will see that all these different substances present in the soil are also present in the plant, but the proportions differ. You will observe that in the ash of wheat, oats, barley and rye, potash exists in the proportion of about 23-100, whereas, in the soil, the same ingredient is present in but a comparatively small proportion. So with phosphoric acid; it constitutes nearly half the ash of the grains, whereas in the soil it is exceedingly small. Now, this phosphoric acid, though present in small quantities in the soil, is so necessary to the growth of plants that they are found to contain a large proportion of it. Now, [pointing to the table exhibiting the composition of the ash of straw,] it will be seen that the straw contains but a small quantity of phosphoric acid. Potash in Indian corn is very like that in wheat. The straw of wheat contains a large proportion of silica; the ash of grain a large proportion of phosphoric acid. This acid rises as the plants grow, while the siliceous matter comes in by the roots and lodges itself in the straw. We see similar differences if we look at the composition of the ash of our green crops, as the turnip and potato; the potato is more than half potash, while the phosphoric acid is small compared with that in the grains. In short, every plant, taken as a whole, contains these things in proportions different from any other plant; and plants of different kinds or families differ materially. So different parts of the same plant contain these substances in different proportions. What is the inference from all this? Suppose a plant to be growing; it must get from the soil those substances which it most requires. If, in forming the flower and perfecting the seed, these substances must flow up readily, and the soil must furnish them in sufficient quantities, or the plant must cease to grow rapidly, this shows the practical applications or results that we shall arrive at—to which practical men have not yet done—but which when we shall have reached a system of refined Agriculture will enable us more intelligently to adapt our modes of cultivation to the growth of plants; and to that we shall come bye-and-bye. But to the practical application of these facts. First, you see what plants grow better in some soils than in others; that if plants grow well on a given soil, it must be because that soil supplies the wants of the plant. Now, some soils contain very little phosphoric acid; if the soil contains much potash and you put upon it a plant requiring little, it will not grow well, whereas, if you put upon it another plant requiring a great deal, it will grow well.

When speaking of the relations of Geology to Agriculture, I showed you that the kind of trees growing upon different tracts of land indicated differences of soil—differences arising from the geological confor-

mation of the country, but they are in reality the result of chemical differences, or of differences of materials that enter into the soils, and which determine the trees that grow upon it. So with crops; if you select any soil and undertake to grow plants there, for a time they will grow well, just in proportion as the soil contains what the plant requires in greater or less abundance. If it requires a particular substance in large quantities, the continual growth of it will exhaust the soil. Let me explain this word exhaust. Suppose you plant green crops, as the potato, for years in succession, without adding anything to the soil, if the crops are large, you will take a large quantity of potash, particularly from the soil; besides taking out a portion of other matters belonging to the soil, it selects this potash in large quantities. After cropping for a long time, the land will cease to grow the potato, because of the exhaustion of the potash. This is what is called *special exhaustion*, that is, there may be enough of other substances left to grow the potato. Hence, in many instances, the addition of wood ash has been found to be a simple mode of making the soil grow the potato. Now, suppose in a case of exhaustion, that you introduce a crop that contains or requires but little potash or much phosphoric acid and alternate this crop with the root crops, it is obvious that the soil will hold out longer, because in that case, you do not draw so constantly on any one substance in the soil. This is one reason for the rotation of crops, and the most skilful rotation is that which is governed by these rules. Thus you see the meaning of the two terms, general and special exhaustion. Land is *generally exhausted* where this alternation is pursued for a long series of years, and will remain so until all those things are added which have been taken from it, in sufficient quantities to feed the plant. If I grow one crop continually, and that crop requires one thing to be present in the soil in large quantities, I exhaust it of that one thing only, and I can add that and restore the soil, if I know what that is. This is the great object of the researches and labors of science in this direction—a kind of labor requiring more study than you can well understand at a glance. The great object is to understand what a plant takes from the soil and what to put in to bring it back again.

Prof. J. illustrated this point by showing that a system of cropping might be adopted, which would lead to a partial exhaustion of the soil, and which it was vain to try to bring back again by ordinary manure, but which could be easily restored, and without any great expense, by applying to the soil, the substances which must have been taken from it by that system of cropping. Let me draw your attention, said he, to a fact familiar to you, in this country where there is little intercourse with the large towns, and where the farmer raises or

makes everything at home—his soap, candles, &c. In making soap for instance, you know that the wood ash is essential ; but the farmer, whom I have described, does not take the ash of soft wood, but of hard wood ; he will tell you, that his reason is, that there is no potash in the ash of pine, and so it is in reality. Prof. J. went on to state the quantity of potash contained in the ash of different woods, adding, that the ash of those trees which contain most potash, is the ash of those which grow in soils where there is an abundant supply of potash. Tobacco is a crop that contains much mineral matter. Suppose an acre to yield 800 lbs. of tobacco. These 800 lbs. contain about 160 lbs. of mineral matter, which is carried off as it were, by this kind of crop, and which will ultimately exhaust the soil specially. You may think it remarkable, that in the rotation of crops, first, wheat, then turnips, then barley, then clover, then wheat again, a very common rotation, mineral matter may be carried off to the extent of 1300 lbs. per acre, you would naturally suppose that this would exhaust it more than tobacco, which in 4 years carries off 600 lbs. per acre ; but here is the difference : we do not sell off the straw ; we return that to the land in the form of manure, and by this means, the yearly loss is confined to that which is contained in the grain ; the grain contains only 83 lbs. for 4 years ; whereas tobacco carries off 600. Of course, tobacco exhausts the soil far sooner ; that, I repeat, is special exhaustion, and knowing what tobacco carries off, we can supply it.* One other ob-

* We give an analysis, taken from Prof. Johnston's lectures, 2d edition, of the ash of the tobacco leaf, and the composition of a special manure for tobacco :

Potash,.....	12.14
Soda,	0.07
Lime,	45.90
Magnesia,.....	13.09
Chloride of sodium,.....	3.49
Chloride of potassium,.....	3.98
Phosphate of iron,	5.48
Phosphate of lime,.....	1.49
Sulphate of lime,	6.35
Silica,	8.01
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All the ingredients which are necessary to replace 100 lbs. of the ash of tobacco leaves, are present in the following mixture :

Bone dust, sulphuric acid,	23 lbs.
Carbonate of potash, (dry,).....	31 lbs.
Carbonate of soda, (dry,).....	5 lbs.
do magnesia,	25 lbs.
do lime, (chalk,)	60 lbs.
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	144 lbs.
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ervation, as to the particular operation of this. You see how a knowledge of what the plant takes from the soil, is necessary to know what is the nature of exhaustion, and what to put into the soil to bring it back again so far as mineral matter is concerned. The organic matter plays an important part in the growth of plants, but I do not speak of that now. But you see how a knowledge of the inorganic substances taken out by a series of crops enables us to show what to put in. But it does more; it enables us to prepare manure which shall contain all the mineral matters that the crops have taken out, and to make special manures adapted to special cases. I have prepared tables of special manures thus adapted, in order to restore to the soil what the crops have taken from it. This is important, for it points out how to manufacture what a farmer wants to promote the growth of any crop, and to restore land to fertility which has been exhausted. I do not pursue this matter further. I think I have shown you illustrations enough to satisfy you of the value of the application of refined chemical research to the plant, and, that though complicated, they have a practical bearing on the every day business of the farmer, and to show you how many kindred branches of science have been actually brought to bear directly upon the pecuniary profit of his pursuit.

At our next meeting I shall show you how science has been brought to bear on the rearing and feeding of stock, and shall present to you considerations on this topic which can scarcely fail to interest you; and you will then see that this wide field of science, over which the practical farmer may travel with advantage, becomes wider and wider with every step that he takes.

LECTURE SEVENTH.

RELATIONS OF CHEMICAL PHYSIOLOGY TO THE ANIMAL—ITS FOOD AND ITS GROWTH.

GENTLEMEN: The subject which I propose to introduce this evening is an exceedingly wide one, as indeed I may say of all the subjects of which I have treated. At the same time, I think the points I shall be able to present this evening are so plain and intelligible that you can see plainly the width of the subjects of which I treat. You will recollect that at our last meeting I presented to you the composition of the elementary part of the plant; and I showed you, that if you take any part of a plant and burn it, that by far the largest portion burns away; that the part that burns away consists of four elementary substances, carbon, hydrogen, oxygen, and nitrogen. These three last being different kinds of air. I showed you, also, how they differed and how they were to be distinguished. It is necessary to re-introduce this, to make you acquainted with what is called the ultimate composition of the organic parts of plants, animals and soils. I wish to make use of these words, and unless previously explained you would not be able to follow them. First, I draw your attention, not to the elementary constituents of plants, but to the substances that exist in the plants which we eat; for example, the great mass of this rod consists of woody fibre; then, if you take a grain of ground wheat you know that it contains much starch; that is another substance that the plant produces. The sugar cane produces sugar; this sugar exists in all plants. These substances all consist of the elementary bodies spoken of. There is no nitrogen in these I mention, but others contain it. Now, of the crops we cultivate these three substances, woody fibre, starch and sugar constitute a very large proportion. But before I show you of what they consist, and in what proportions, I must explain to you the nature of the important substances existing in the plants which we cultivate for food.

If you take a quantity of wheat flour and make it into a dough, and put this dough on a piece of muslin, tied over a glass and pour water

on it, the water will pass through the muslin in a milky form. If you continue the process until the water passes through quite clear, a substance will remain, which the chemists call gluten. The milky substance which passes through the muslin, falls to the bottom in the shape of a white powder—that is starch—thus I separate wheat flour into starch and gluten. Now, this gluten contains all four of the elementary bodies I have named—it contains about 16 per cent of nitrogen—hence the nitrogen in the atmosphere is of great importance in the growth of wheat. Take any vegetable substance—the straw of wheat or of this piece of wood ; and it contains a great quantity of fibrous substance called woody fibre—that exists in all plants. If you take this gluten and put it into spirits of wine and heat it, you can extract from it a quantity of oil. So with Indian corn, or oats, and from the stalk and straw of either you can extract more or less oil. We have then, first of all, the woody fibre, we have starch, and gluten, and oil ; these four are important to the nourishment of animals and exist in all plants. But before showing the importance of these substances to the growing animal, I must show you the proportions in which they exists.

*Average composition of 100 parts of the more common grains
roots, and grasses, &c.*

	Water.	Husk or woody fibre.	Starch, gum & sugar.	Gluten al- bumen, &c.	Fatty matter.	Saline matter.
Wheat,	15	15	55	10 to 19	2 to 4	2
Barley,	15	15	60	12 to 15	2 to 3	3
Oats,	16	20	60	14 to 19	5 to 7	4
Rye,	12	10 to 20	60	10 to 15	3 to 4	2
Indian corn,	14	6	70	12	5 to 9	1½
Buckwheat,	15	25	50	8	0.4	4
Rice,	13	3	75	7	0.7	0½
Beans,	14	8.11	40	24.28	2.3	3
Peas,	14	9	50	24	2.1	3
Potatoes,	75	4	18	2.0	0.3	1
Turnips,	88	2	9	1.5	0.3	1 to 4-5
Carrots,	85	3	10	1.5	0.4	1 to 2
Mangel Wurtzel, .	85	2	11	2.0	?	1 to 1½
Meadow hay,	14	30	40	7.1	2 to 5	5 to 10
Clover hay,	14	25	40	9.3	3 to 5	9
Pea straw,	10 to 15	25	45	12.3	1.5	4 to 6
Oat straw,	12	45	35	1.3	0.8?	6
Wheat straw,	12 to 15	50	30	1.3	2 to 3½	5
Barley straw,	12 to 15	50	30	1.3	?	5
Rye straw,	12 to 15	45	38	1.3	?	4
Indian corn stalks	12	25	52	3.0	1.7	3 to 7

Some of the above numbers, are approximations, only, especially the fatty matter, which is very uncertain, and the buckwheat.

This table contains all we know of the composition of crops, you see that there is water in all this food. Wheat contains 15 per cent of water, the turnip from 88 to 90 per cent—showing the

*For an analysis of Indian corn, by J. H. Salisbury. see Transactions of 1848, p. 678.

difference between grain and roots. The next column represents the woody fibre which animals cannot digest, and in which there is no nourishment. This in wheat and other grains varies from 10 to 20 per cent. Here are starch and sugar. Wheat contains about 55 per cent of starch; and here I must speak of this substance, for it affords us an exceedingly beautiful illustration of the relations of the plant to the animal, especially to the life of the animal, and again of the animal to the life of the plant. About half the weight of wheat consists of starch. So with barley, Indian corn, rice, peas and beans. Then all grains contain a substance analogous to gluten, but varying in this, that all do not contain the same quantity. Of this gluten, there exists in flour from 10 to 19 per cent, in barley from 12 to 15, in oats from 14 to 19, in rye 15, in Indian corn 12, in rice 8, in buck wheat 8, in beans and peas from 24 to 28, which is much more than is contained in any of the grains, and hence these produce the greatest effect upon certain functions of animal life. In the potato and the turnip it is very small, for nine-tenths of the turnip consist of water. Pea straw is very rich in it; all other straws are comparatively poor. Wheat and barley have little oil, oats from five to seven per cent, Indian corn five to nine, beans and peas from two to three per cent. Therefore these latter are deficient in oil. You find, going down, the quantity is small in the roots. So with the straws, they contain but little oil. Prof. J. here pointed to a diagram, showing the quantity of saline matter in the ash of different straws. Now there are two things of which I must remind you: 1st, that of all these different kinds and forms of matter which exist in all plants, but in different proportions, gluten, starch and oil are largest in the grains. Starch is the largest in the grains, gluten larger in the grains than in the straws, except pea straw, and is largest of all in the beans and peas. Oil or fat is greater in the seeds, and especially certain seeds, cultivated for food, greater in the oat and Indian corn than in other plants. Linseed I shall speak of, though this is cultivated for the oil and not for food, yielding about 60 per cent of it. Now these substances exist in all foods in different quantities. But how are these substances formed in the plant? where does the plant get them? This inquiry renders it necessary for me to make you acquainted with a principle of great importance to a clear understanding of the relations of different kinds of animated nature, one to another, the relations of the plant to the soil and of the soil to the animal. Time will not permit me to introduce some interesting substances existing in the soil from which plants are enabled to build up these kinds of food. But I will remind you, by way of illustration, of an experiment made at our last meeting. I took a little limestone and

poured on it a quantity of acid ; I now repeat that experiment. The effervescence is owing to the evolution of a kind of air called carbonic acid gas, one property of which was that it extinguished a taper when put in it ; another was, that it could be poured out from one vessel into another ; it is called acid, because in reality it is sour to the taste. This carbonic acid consists of two of the elementary substances of which I have spoken, carbon and oxygen. This carbon exists in plants and forms a large portion of the wood, as the gluten and starch and fat do, of the seed.

Perhaps you will recollect that I explained the structure of the leaves of plants, and showed how the under side, particularly, was studded with numerous pores or apertures, through which the plant sucked in certain substances from the air. I told you at our last meeting, that the leaves of plants, spreading through the air and exposing the large surfaces to it, sucked in this carbonic acid gas, which exists in the atmosphere in a very small proportion. This table, (pointing to a diagram) represents the proportion of carbonic acid gas which exists in the atmosphere. You will see that but one gallon of this air exists in 2,500 gallons of atmospheric air. The leaves of plants, through these little pores, suck out this gas from the atmosphere, in order that after undergoing certain chemical changes, it may serve to build up the substance of the plant.

What are these chemical changes ? The plant sucks in the carbon as long as the sun shines. This carbonic acid gas consists of carbon and oxygen, and the plant sucks it in while the sun shines ; but the leaves, at the same time that they suck in the carbonic acid, discharge very nearly as much oxygen, as they take in of oxygen in the form of carbonic acid ; that is, if the leaf sucks in a given volume of the two gases combined, it discharges the whole of the oxygen which it contains, and retains the carbon ; therefore, the function of the leaf is to suck in carbonic acid and throw off oxygen ; to retain the carbon and throw off the oxygen. But it retains the carbon, not as charcoal ; on the contrary, the plant exhibits green leaves, having no appearance of charcoal about them. But it undergoes certain chemical changes, the result of which is, that the oxygen is given off, and the carbon becomes a new substance. That is one source from which the plant derives the food, out of which the different substances in the table are formed.

This illustration of the way in which leaves take in sustenance from the atmosphere, shows you the mode in which plants, through the roots, as well as leaves, take in their food and convert it into another form of matter, the result being a change of what is thus taken in, into

starch, gluten and fat, which are found in all plants, and which are important to the nourishments of animals.

I shall not dwell on this now, but come back to it before I conclude, having made you acquainted with the fact, as far as necessary, to enable you to understand the general principle I wish to fix on your minds, in regard to the composition of plants. I now draw your attention to the composition of animals.

If I take any portion of an animal, for instance, the end of one my fingers, and burn it, a large portion will burn away, and there would remain behind, also a large portion. The larger portion of the finger, the bone, would remain, in fact, being nearly the whole of the original bulk. So, if I take a piece of flesh, and cut off a bit of this muscle, excluding both the fat and the bone, and burn it, I find that a large portion burns away; but there remains a quantity of ash. Here we find precisely what we find in burning the plant. Every part of the plant which burns, leaves behind it, a mineral matter or ash. So it was with the soil, and so we find it now with the animal. These general relations between the soil, the plant and animal, all resolve themselves into the fact, that all of them consist of a part which burns away, and a part which does not; of the soil, the part that burns away is small; in the plant, it is very large; but in animals, we find both of these conditions; the soft parts of the animal, bear a similarity to the plant, in that the quantity which burns away, is greater than what is left; but if you burn the bone, there will remain a large quantity of mineral matter, the ash of the bone is greater than what burns away. Thus a quantity of mineral matter is left by every part of the animal which is burnt, and the quantity varies with the part of the animal which we burn. But I do not dwell on the mineral substance left. I draw your attention to the organic part that burns away. Look at this piece of beef. Here are three different substances; the muscle, or red part, the fat, and the bone. Now, in every part of the animal, leaving out the viscera, you find these three forms of matter exist; the fat, the muscle, and the bone.

Consider these different substances. The fat has a strong analogy to the fat existing in plants. If I take a portion of the fat—the suet as it is called—and put it under a press, I can squeeze out oil, which shows that in this solid fat, liquid fat is present. From this, candles may be made, soap &c. I have said that this is analogous to the fat in plants. Take olive oil, for instance; in winter, it becomes a solid lump of fat, but, put it under a press and you can squeeze out an oil, that will not freeze, and it will leave a substance, that is oily and that will

remain solid even in the summer. Here you see the analogy between the fat of plants and that of animals. The solid fat of olive oil is the same as the solid fat of animals. If I eat olive oil, I eat solid fat, precisely like that of my own body. But I pass over this, believing that you will concede to be true what I cannot explain further—that the fat of all animals has a relation to the fat of all plants.

Now take this muscle, colored by blood—cut it out and wash it with water, until you wash out all the blood, you get a perfectly white substance, which can be drawn or torn into fibres. This is called fibrin. Now this fibrin is almost identical with the gluten of plants. Here then, is another analogy between the plant and the animal. Therefore, as the fat of animals is found to be identical with that of plants, so the muscle of animals is almost identical with that part of the plant called gluten.

But how with the bone? In plants there are no bones, we have a hard substance, which is not bone but which is sometimes very hard, as the wood of ebony. Burn the wood of plants and you have a small quantity of ash; burn the bone of animals and you have a large quantity. In tracing out the analogy between plants and animals, let me draw your attention to the bones of animals. Here is the bone of the ox; the cartilage will burn away, one third of the dry bone will burn away. Now of the phosphate of lime 57 per cent exists in the bone—phosphate of lime consists of phosphoric acid and lime. You recollect, I told you that phosphoric acid and lime both exist in plants—and in the ash of the grain of wheat, to an amount equal to one half of the whole bulk. You see therefore that we have in the bone and the ash of the bone, those substances which seem to form the largest proportion of the mineral matter existing in the different kinds of food that we eat, and also in the food for cattle. Where does the animal get these substances forming the different parts of the body—the muscle, the fat and the bone? It is obtained from the food which is eaten; but observe, that whilst the plant draws from the soil and from the air, one form of matter, and converts it into another, as for instance, carbonic acid gas—does the animal do it? No: on the other hand, the animal takes in, not the raw material, as it were, but the material already produced by the plant—the animal takes in this gluten, in the form of bread or grain, which gluten is almost identical with the solid part of the muscle. The animal also takes in fat with its food. Whether we eat vegetable or animal food, we take in fat substances closely related to the fat of our own bodies; and in regard to the bone, we take in food that contains the material which forms the mineral matter of the bone

itself. Therefore, though the plant bears this relation to the animal, the plant could exist without the animal, but not the animal without the plant. The animal could not suck in the atmosphere and convert that into the solid parts of its own body—it is so ordered that the plant drinks in from the air, certain substances, and certain other substances from the soil, which are necessary to its growth, just as we would take a purse from the pocket and select a piece of money taking out of both, what it wants, and nothing more. So when food is introduced into the stomach, it is immediately placed in contact with the digestive organs, which perform the same office for the body, as the leaves do for the plant. The stomach has its peculiar functions and selects from the material that the plant has prepared, the very things which are needed to build up the several parts of the body, which require to be built up. But there is a difference which I must explain, I have shown a strong analogy between the plant and the animal, we have seen that both contain fat and gluten. But I said I would draw your attention more particularly, to these substances. Starch, we find, exists in wheat, to the extent of half the weight of the grain, and we eat with our food, a large quantity of starch. Is there any starch in the human body? No! Here then is the striking difference to which I have alluded. We find that in this food, which is supposed to be especially made to sustain the human family, viz: the grains, we find starch forms nearly half of the whole bulk. What is the end or purpose of this? To understand this, it is necessary to explain one or two functions of the animal.

Living animals perform various functions. The food they eat is digested; that is the most important function; but we cannot compare the importance of one function with another, in the living animal; for if any one function ceases to be carried on, the animal ceases to live. But what is the distinction? First of all, the food is dissolved in the stomach, and by means of the organization of the stomach, the animal selects from it, the materials necessary for such parts as need it. But the animal breathes. Stop our breath, and we could not live a moment. What is the effect on animal life, of breathing? Here is the difference between plants and animals. Compare the composition of air, before it goes into the lungs, with its composition, when it comes out; you will find that the air comes out, charged with a greater quantity of carbonic acid gas, than when it went in. In its passage through the lungs, the volume of this gas is greatly increased. This carbonic acid comes from the blood of the system; it consists of carbon and oxygen, and is obtained from the food. The animal, in fact, draws in air, and

throws out air of a different composition; the oxygen is diminished, and the carbon increased.

Of what does starch consist? Of carbon in large quantities. When the leaves draw in carbonic acid they throw off oxygen; the carbon only remains, and that in a new state of combination; it forms starch among other things, by uniting with water—starch in fact consists of carbon and water only—so that in forming starch the carbonic acid unites with water in the plant. It forms starch, which the sap of the plant conveys to the part which requires it. We find it largely in the seeds. Now, the function of the leaf is to change this carbonic acid and form starch. The animal takes this starch into the stomach and decomposes it, and it escapes from the lungs in the state of carbonic acid and water. I say water, for if I take a clear, dry glass and breathe into it, it makes it opaque; the moisture of the breath being condensed upon the cool glass. The lungs, therefore, are continually throwing off carbonic acid and water, and these are thrown off at the expense of the food which the animal eats; that is, the starch which is conveyed into the stomach in the form of food, is by certain animal processes, converted into carbonic acid and water and thrown off by the lungs. If I take a piece of starch and kindle it, it will burn much like wood, and give out heat and light; and when it gives out this heat and light it is converted into carbonic acid and water, or into the same things exactly as it is by the respiration of the animal. Thus the functions of animal life convert starch into the same substances as when we burn it.

You will ask, what is the purpose of all this? The plant sucks in carbon and water, and the animal takes it in in the shape of food and discharges it again in the same form. Is this designed for the mere amusement of the animal? No; the purpose is this: animals require to be kept warm, and among the means to keep up warmth one is the application of external heat. It is also kept warm by its food. The animal that is stationary will keep itself above the temperature of the air without the application of heat, because the animal has within itself a source of heat; and just as when starch is burned it gives out heat, so in the interior of the body—though it does not burn as rapidly, and gives no light—yet it undergoes a slow chemical change, which is known to produce heat, that keeps the body warm, and thus starch serves to keep up the animal heat. That, at least, is the present opinion. The animal takes in this starch with its food, the plant mixes it up with what the animal eats. The animal must eat starch with other substances, and thus the animal cannot eat what will not supply the materials to enable it to discharge all the functions of the body. Na-

ture mixes up these things in order that respiration may go on, and that the animal may be kept warm, and provides also that the plant may undo what the animal has done, and thus renew the substances necessary to keep up the animal functions.

You cannot fail to see how very beautiful this cycle is. Here is a continual operation going on, by which the carbonic acid and water of the atmosphere are converted by the plant into food, one of the component parts of which is starch, and by which it is again returned to the atmosphere, in the state of the same carbonic acid and water. But there are larger cycles than this, on which the existence of animal life depends.

To advance one step further: You see now the reason why it is that the plant differs from the animal, in that it contains this large quantity of starch. But what is the relation of other kinds of food that the plant contains, to the animal? What is the function of gluten, or that substance which we have found to be nearly identical with the fibre of the muscle? When the animal eats vegetable food, it eats a portion of this material, which is so nearly identical with its own muscle. You understand, no doubt, that if certain parts of the animal are building up or increasing, why it is necessary to give it continual supplies of that substance, from which the muscle is built up. If this is what supplies the growth of muscle, you might say that if the muscle is fully formed, it is not necessary to keep it up; that if this substance is introduced into the stomach, and the gluten is selected which goes to form the muscle, that the gluten, in such a case, is not wanted. But this is not so; this law exists, though the body may appear to be identically the same, yet it is continually changing and undergoing renovation in different parts. There are certain parts, of every portion of every animal, removed every day, and a quantity of new material put in its place, so that the body is kept up by the continual addition of new matter.

The way this takes place may be thus illustrated: Suppose you have a scar that has remained as far back as you can recollect: if this doctrine be true, that the whole body is renewed once in five years, you may well think it curious that this little mark should remain so long, without any apparent change in its appearance; but it is in fact, engraved as it were, not on the matter originally injured, but on other matter. You can understand this, by this simple illustration: Suppose this building to be of brick, and that every day some small part of it is taken out, a brick from this or that place and a new one put in, until the whole building has been renewed, and yet no apparent change in it beyond the color of the new material; for you can conceive how such a

process might go on, until every part of the building had been replaced by other materials; and yet the building remain a complete building in all its parts, its interior accommodations and its outward proportions. This is constantly taking place in your body; from every part of it a portion is removed every day, more or less, according to the quantity of material taken in, in the shape of food. Hence, the animal should have a constant supply, in order that this daily waste may be made up. An animal requires to sustain its body in good condition, or to supply what is called the sustaining food, about one-sixtieth part of its own weight, and to keep it in condition, one-fiftieth or one-sixtieth part of its own weight, every day, to sustain its daily waste. If you want to give it food, to increase its size, to enable it to do work, or to produce milk, then you must give it more food. If you feed it for milk you must give it twice that quantity. You must adapt your food to the points for which the animal is fed, and you can do this, for the art of feeding animals with a view to certain results, is one of those arts which science has given to the farmer. If I want to lay on muscle, I must give food that contains gluten, and looking over this table (pointing to a diagram) you will see that beans and peas contain this in the largest quantity, and you know how important an article of food beans and peas are for horses and cattle, particularly for working horses. Cabbage contains about nine-tenths of its weight of water. Wheat, 35 or 40 per cent of gluten, or of this matter from which muscle is formed. The flower of the cauliflower contains more of gluten than any substance we raise for food. If you want to lay on fat, you will give the animal food that contains more fat, such as Indian corn; so if you want to give it a good coat, you will give it oats or Indian corn. You can make an animal fat by giving it fat, but in general we select seeds or grains, such as linseed, that contains a large quantity of oil, sometimes twenty per cent. Rape-seed contains 70 per cent, and poppy-seed contains a great percentage of oil. In Flanders and France and other parts of Europe, it is cultivated for its oil. The cake which is left after expressing the oil, is exceedingly nourishing, and can be used advantageously in feeding cattle. This poppy cake does not contain opium enough to hurt an animal; when seed-cakes are employed to feed animals, oil cakes are imported for this purpose. Here is a table of the composition of oil-cakes. Three different varieties can be made. This oil-cake contains what forms muscle and fat, and farmers know that to lay on muscle and fat, it is a most profitable kind of food. But the animal is often fed for milk. Now milk has three different qualities. The milkman

wants quantity and not quality, and therefore he gives his cattle grains from the brewery—drinks of various kinds and water—and if he finds, after all, that the milk is too rich, he puts a little water in it [laughter.] But where the dairyman wants butter or cheese, then he wants quality. If he makes butter, the milk should be rich. He can add largely to the ordinary produce of the dairy, by the selection of food, rich in oil. In England, we give them oil-cake, but not much at a time, as it gives an undesirable taste to the butter; but this is the result rather of inexperience, for the skilful dairyman, finds he can give a large quantity of oil-cake and get a far better quality of milk than by giving any other food. So if he wants milk for cheese, he gives the food that is rich in the material to produce curd—that is precisely the food that produces muscle—and when I tell you that that which produces muscle produces the curd in the milk of the cow, you then have a clue to the mode in which animals should be fed, when you desire to produce certain results. If I want a poor cheese, I would give the animal cabbage, which contains little fat, but a large quantity of the muscle-forming or curd-forming material—it produces a milk poor in cream and butter, but rich in the material that forms curd. But if I desire milk for butter or rich cheese, I give more fat, and of all the materials that we know of, linseed oil-cake is the best.

I do not dwell on the feeding of animals, for growing young calves. When the animal is growing it is necessary to adopt the food to its condition. You must give it such food as is necessary to increase the bone. The cow in calf must also have a supply of food in proportion to its condition, so if you are rearing young animals you must give food to preserve the milk of its natural consistency, but we in England feed animals with a view, merely, to fill up the farm yard with manure. The farmer does it not for profit in such cases from his animal, but from the richness of the manure. Under all circumstances the kind of food should be selected with reference to the result of analytic research, and according to the purposes for which the animal is fed—regarding also the food which is the cheapest in market or which is most readily within reach.

One of the circumstances, (for I have but five minutes more and must hurry over this part of the subject)—it is of great importance to attend to, the state in which the food is introduced into the stomach. If I select Indian corn without mixing it with other food, the animal cannot digest it readily. So with other food, this shows how important it is, that the food, whatever its composition, if it is to produce its full feeding effect, should be given in such a state that the animal can avail itself of it. The feeding

of animals with prepared food, is a branch of knowledge which has resulted in great profit to the farmer. A mixture of different kinds of food is better than one kind; better, because it is of different kinds, than because it has different compositions, and by mixing food we are more likely to meet the wants of the animal. When food is mixed with cut chaff, it is far more nourishing; in short, food goes further, and performs its functions more effectually, when mixed up in this way. Now, you have all heard of malt being used in feeding stock; malt differs from ordinary barley from its being sprouted a very little, and dried. Barley contains starch and gluten; when it sprouts, a certain quantity of gluten changes its character, being converted into a substance soluble in water. If you take malt and crush it, and put it into water, the water will dissolve out this substance, which is found at the root of the germ; and the water, when poured off, will dissolve starch. Put starch into water and it will not dissolve, but it will dissolve in this water thus poured off. Take malt, then, as prepared by the brewers, and put it into the food for cattle, and it performs in the stomach the process of dissolving the starch in the food. This is a reason, not why malt is not more nutritive than barley, but why malt may be profitably used when mixed up with other food, as it expedites the conversion of the food into a liquid form, and is more nourishing.

I should have made you acquainted, had I time, with another thing, and that is the influence of the circumstances in which the animal is placed on the effect of his food—such as the influences of warmth, shelter, ventilation, quiet. All these circumstances have a great effect on the influence that the food which he gets has on the animal. I have a table of the effects of warmth and shelter, made up from experiment, and showing results of the character which I have intimated; but I have said quite enough to show you that in addition to the state in which the food is given, which modifies the effect of that food, the circumstances in which the animal is placed make the food more or less nutritious. I think you cannot fail to have seen in this interesting department of science, which I have merely run over—for the time would not permit me to go into the details—is not only one of great importance to the practical farmer, but as worthy of his consideration, and as closely connected with the development of Agriculture, as an art, as any of those branches which it has been my happiness to lay before you.

To-morrow night I shall show you, how the pursuit of this branch of study throws light on the common practical operation of the farmer in improving the soil, by manures.

LECTURE EIGHTH.

RELATIONS OF CHEMISTRY TO THE DOCTRINE OF MANURES.

GENTLEMEN :—The subject of the lecture this evening is, The Relations of Chemistry to the Doctrine of Manures, or in other words, the improvement of the soil by chemical means. You will recollect, after I discussed the composition of the soil, and showed you, that when fertile it contained always certain substances in various proportions, that I then drew your attention to the modes in which the soil might be improved ; that I stated there were two methods of doing this, one mechanical, the other chemical, and that I discussed the mechanical method, which consisted chiefly in deeper ploughing, subsoiling and draining. The improvement of the soil by chemical means, is more important, though no one result is more important than another to the farmer, except as one is more profitable than the other. It is quite certain, that no chemical improvement whatever, can result in higher profit than one or other of the mechanical modes I have stated : ploughing deep, subsoiling and thorough drainage. Still, supposing the soil to be already improved in this way, then come in the new, or chemical methods, by which it can be still farther improved, and it is one of those indirect advantages resulting from thorough drainage, that after it has been introduced and the soil made dry, you can then employ the means which chemistry puts within your reach. But if not thus improved, chemical means often prove ineffectual.

As to the chemical mode, it is what we understand by manuring, and by manure, we understand anything that feeds the plant, and corresponds with the food given to animals. Now, to understand fully every substance employed as a manure to feed the plant or prepare food for it, we must know what a manure should contain, and why it should contain these things. But as preliminary to the answer to this question, we must inquire what kinds of food the plant needs, if the object or purpose of manuring be to supply food to the plant. Thus, if we know what food the plant requires, then we know what manure is to be put on. I explained the evening before, that the plant consists in great part, of two forms of matter, one of which, and by far the greater part, was the organic form of matter, and that the inorganic or mineral part

was the smaller portion. In explaining the organic part, the starch, gluten and fat, and the woody fibre, I told you that there were certain elements of these substances, which the plant derived from the air, in large proportion, and certain other elements from the soil only, and that of those elements derived from the air, nitrogen was one only. I told you that the mineral part or ash, is wholly from the soil. Now, all manuring is applied to the soil ; therefore, whatever the plant draws from the soil, these substances or manures should contain ; and the first thing we must study in regard to manures is, what they should generally contain, if they are to make all plants grow under all circumstances, for we may have a very barren soil, and which itself would produce no crop whatever, as you recollect I showed you on a previous occasion. Now, on such a soil, if you apply a manure which shall make any crop grow, then you know, it should be such as should bring it up to the kind of land called fertile. These general manures should combine all that a plant requires to build it up, the nitrogen, which I call gluten, and these mineral substances, lime, potash, magnesia, phosphoric acid, and chlorine. All these substances, this manure must add to the soil, if it is to make plants grow under any circumstances.

In considering the different kinds of manure, our attention is drawn to three different classes of substances, which naturally present themselves in divisions: 1st, vegetable manure ; 2d, animal ; 3d, mineral. The one derived from vegetable substances, another from parts of animals, and the mineral, from the substances occurring in nature, or which can be extracted from rocks ; and there is a fourth class, more important, perhaps, than all ; those which result from the application of science to this subject, viz : the artificial manures, which are compounded with reference to what we know to be the wants of the plant. Let me draw your attention to these manures, with this preliminary observation, however, that though we arrive, from these considerations, at certain conclusions, as to what the plant requires always, that is certain organic and mineral matter ; yet we cannot be sure that certain vegetable or animal or mineral substances contain them all ; but we can be certain that those manures, which we make up, shall contain them all. As to the several kinds of manures ; and 1st, the vegetable manures. They are applied 1st, in the green or in the dry state. Green manuring is the turning into the soil vegetable matter which is growing ; as when a crop of clover is ploughed in, or when the sward is ploughed up, and the grass buried, or when green crops, grown for the purpose, are left to decay ; for crops are often sown for the mere purpose of ploughing them in. Leguminous crops are very good ; clover is

very good ; lupines are cultivated largely in Europe and sold for manures. The crop is ploughed in before it ripens. So in northern America, buckwheat is sowed for a similar purpose, and many other plants are sown, to be turned in for manure, when in a certain state. This is one of those methods, within the reach of every man, and which in this country may be used to advantage when the land is exhausted. In many parts of America, where I have been—I do not refer to this State—these exhausted soils occur, and where the difficulty of obtaining these fertilizing substances, except from a distance, is very great. Hence, any method which the farmer has within his reach, and by which he can most easily restore strength to his land, must be the best ; and this method of ploughing in green manure is very effectual.

How does this act ? I have spoken of the lupine, which is analogous to peas and beans. You recollect that last night I showed you the composition of different crops, and among the rest, that of the bean and the pea. You will recollect that they contained 24 or 25 per cent. of gluten, and that even in the straw of these, there is as much gluten as in wheat. The nutritive quality of the straw, of the bean and the pea, would be as great as that of wheat ; consequently, you see in this, one of those deductions, which the analogies of plants enables us to draw. The lupine has this quality ; it is rich in gluten, containing, among other things, nitrogen, which it has taken from the soil only, and therefore if you bury it in the soil, you enrich it with this gluten, which is so important an element to the growth of plants.

Further—by ploughing in green crops, you introduce another element. You know that all plants contain mineral matter ; the bean and pea contain considerable. The roots of a plant go down as far as possible, if the habit of the plant is that way. Beans and peas go down to a great depth, in search of food, and among this food, are the mineral matters of which I have spoken—lime, potash, soda, &c. The roots send this up into the stem of the plant ; they bring it from below, above the surface, or into the stem of the plant. But in this way, they do not get into the material of the surface ; but if you plough in the plant, you supply the surface, not only with nitrogen, but with mineral matter. Thus you employ the roots of the plant to bring up from below what you want, upon the surface. This is the philosophy of green manuring. It does not put anything new into the soil, but it brings up from below, and puts upon the surface that which renders the surface fertile.

But besides green manuring, marine plants are often used—such as sea weed. This is another form of green vegetable matter. It is used on the sea coast ; and in Scotland, it is considered so valuable a manure

that the right of way to the sea-side, adds a large additional rental an acre to lands. Now sea-weeds contain a large quantity of organic and of mineral matter. There is a table, (pointing to a diagram,) showing the composition of sea-weeds—that they contain about ten per cent of mineral matter. They are exceedingly rich in it, as you might suppose from their growing in salt water. They contain some 38 per cent of salt; phosphate of lime is also present in sea-weed; phosphoric acid also. In short, in this form of vegetable matter, we have a certain quantity of what crops require; so that if you lay it on land, or plough it in, it is found to be productive of great benefit.

Besides these forms of green vegetable matter, there are many others, which I pass over; but it is often applied in a dry state. You know there is a form of vegetable matter, such as the husks of grain, known as bran, which is given to cattle, pigs and other stock, for food, as well as to fatten them. This bran contains much mineral and organic matter, of a very rich and fertilizing kind, and hence it is often applied, instead of feeding it to stock, as a manure, and is found to be very beneficial to land, causing it to produce very good crops. But there is another form of dry vegetable matter, used with us, as a manure; it is one of those substances I spoke of last night, viz: the cake that is left when oily seeds are crushed. This cake contains all the remainder of the constituent parts of the seeds, the composition of which, I showed you last night. The linseed cake is too valuable to be used as a manure; but the rape cake, which cannot be much eaten by cattle, is extensively employed as a manure and with great effect. Perhaps I may use this as an illustration of the mode in which our farmers profit by high manuring, and though it may seem to partake of the nature of speculation, it is an adventure which is certain in its results. Suppose here are two farmers, occupying two farms, cultivating each 40 acres of wheat. The one ploughs and manures his land in the ordinary way, and the wheat comes up like his neighbor's; the other, after ploughing and sowing, leaves the rest to providence. He does not trouble himself, except perhaps to take out the weeds, leaving his crops to the influence of the seasons. But the other man does more; as soon as the grain is up, or when it begins to shoot, he applies a quantity of rape cake. This is over and above what the other man does to his land; and for his crops, he gets perhaps 50 shillings worth of wheat for 40 shillings worth of rape dust—besides a great quantity of straw. This is the way in which our farmers, by high farming, make money. It is laying out money in fact, to get it back with interest in another form; and you will readily see what I have often seen, wherever I go, that the man who farms highest, makes the most money.

I pass now to the subject of animal manure. This is of various kinds, consisting of parts of animals; blood and flesh are often employed as manure. In some parts of the world it is dried, and sold in a dried state; sometimes it is dried by artificial heat, and applied in a dry powder, and is an exceedingly fertilizing substance. So with the flesh of animals; dead animals are often buried, as a manure. So the refuse of animals is employed, more or less, as a manure. You know the composition of the muscle of animals: it contains 77 per cent. of water—a solid beef steak contains that amount of water. It will surprise you, perhaps, to know that the blood in your veins, as well as in animals, contains the same quantity of water that the muscle does, and differs from the flesh in no degree. Dry flesh has exactly the same composition as the blood. Burn them both, and the mineral matter left is nearly the same. The ash of the blood and of the flesh contains phosphoric acid and phosphate of lime in large quantities. Both, therefore, are extremely fertilizing, as they contain the mineral matter that the plant requires; and the organic matter that burns away is identical with the gluten of the vegetable, and supplies the nitrogen of which the gluten is built up.

Fish, in many parts of the world, are employed as a manure. On the sea coast in this State, and other north-eastern States, fish are employed extensively as a manure. Muscles, in England, are often buried in the soil as a manure. Sprats, also, are obtained in great quantities, and employed in the same manner. Among other interesting things I have learned in the State of Connecticut, is the fact that fish are obtained there in large quantities, and are now manufactured into a fish cake. The oil is expressed, and the cake is dried, and is found to be exceedingly fertilizing, consisting of animal matter and bones, with a little oil remaining in it. I understand that it is intended to export it to Liverpool. I believe it will find a ready market there. Shell fish are another form of animal matter, applied as a manure. In some parts of northern America, the muscle is found in great abundance in the mud banks on the coast. In England, we use them as I have said; so on the coast of New-Brunswick and on the borders of Maine. These muscles are obtained and ploughed in. So with sea mud; that is a fertilizing substance. I have explained to you, in a previous lecture, how it is that this alluvial mud is so rich, and you will recollect how large a quantity of animal matter it contains.

But among the forms of animal matter most extensively employed in England, where Agriculture forms a species of trade or profession, which is pursued with great intelligence and skill, are bones, and they are ap

plied with great benefit. Hair and woolen rags are different forms of the same thing. The animal matter of the bones is exceedingly rich in nitrogen, and capable of supplying those substances which the root of the plant can take in and enable it to build up the gluten, of which it so largely consists. I shall presently discuss the use of bones in various forms, when on the subject of mineral manures. The farm-yard manure, as it is called, the compost which the farmer applies to his land, is another form of manure, which is very rich when properly treated. It is often poorer than it should be, owing to a want of attention to his own interests which the farmer sometimes exhibits. I cannot enter now into the mode in which this manure is employed; but will make one observation in regard to it. When it ferments, the straw and other such matters contained in it, become more soluble, so that when the rain falls on it, the liquid that oozes from it is exceedingly rich in all the fertilizing substances which the heap contains, especially the phosphoric acid. Here is a table, (pointing to a diagram,) showing the composition of the draining of such heaps. It contains mineral matter in large quantities, the phosphate of lime greatly predominating. But I pass over this, and I draw your attention only to two facts in regard to the manure produced in this manner: First, as to the effect which the kind of food which the animal gets, has on this manure. I have said that to sustain the body of the animal when full grown, or to build it up when not full grown, or to increase the muscle for the market, the food which the animal gets, supplies certain materials; but that after these materials are taken out, by the operation of the stomach, all the rest is rejected by the animal. Now, if the food is very rich and supplies more of this nourishing matter than the body requires, the richer the droppings of the animal, and the richer the manure of the farm-yard, than when the contrary is the case. This is so well understood by cattle feeders and those who have poor lands to cultivate, that they feed cattle high, simply to produce a rich manure. This is done, not directly for gain, though the cattle are sold to the butchers, for they often do not pay for the oil cake on which they are fed.

Our Norfolk farmers sometimes feed out a ton of oil cake a day to their cattle; not to make money by the sale of the cattle, but indirectly, through the richness of the manure obtained by it. In Lancashire, where there was a large tract of very poor land, which thirty years ago was a complete moor, in the middle of which was erected a high tower, so that the traveller might know where he was, this great moor is now reclaimed and cultivated, and pays 20 shillings rent annually, per acre. But it is kept in this state of cultivation by this high

farming. They keep cattle, feed them with oil cake, and though the cattle may not be worth half the oil cake used in feeding, yet they obtain in this way a manure, which enables them to raise barley and wheat crops, sustain their families, pay their rent, and lay by something.

Another consideration, is the form in which the food is given to the animal. I explained last night, that feeding is carried on with most profit, when the food is prepared, various kinds being mixed up together. That is found to cause the oil cake to go further in the production of a rich and bulky manure. Here let me call your attention to an important point. You know that from an early period it has been taken for granted that vegetable substances are richer as a manure, after passing through the animal, than when applied in their natural condition. If you take a ton of the droppings of the horse and the cow in a fermented state, it is far more valuable as a manure, than a ton of the substance with which the animal is fed, though it be oats, or other rich food. Every man knows that. Now, this fact was early presented to me for an explanation, and having satisfied myself of the fact, the reason suggested itself. I have shown you that all the different kinds of food given to animals, contain a certain amount of mineral matter, which the plant contains; it contains that form of matter, called gluten, which is rich in nitrogen and starch also. Suppose an animal is fed on wheat, which contains a great quantity of starch, gluten and mineral matter; but when the animal undoes what the plant had done, that is, converts the starch into carbonic acid and water, by the action of the lungs, it separates the starch, which in wheat forms more than half of its weight, and all the other matter—the mineral matter and the gluten, become changed into another form of matter, and what the animal rejects, is richer in saline matter, and in the material that contains nitrogen, than the food in its original state. It contains double the quantity of nitrogen. This is a very beautiful and interesting fact, showing that by the digestive organs of the animal, you can obtain a manure richer than the vegetable and green food, if applied directly to the surface. Another point: the animal grinds down the food into a minute state with its teeth, and it is thus converted into a substance more available to fertilize the soil, than the dry straw or hay which it eats, if applied directly to the soil without mastication.

Among other forms of the droppings of animals, those of birds are employed in large quantities. But among the kinds of this form of matter, most extensively employed, is what is called the guano. In

England, something like 100,000 tons of South American guano are used every year. It is imported at a large expense, and the demand for it is such, that the islands near the coast of Africa, and other parts of the world, from which it was first taken, have become exhausted. The value of these, as a manure, depends on their containing a large proportion of mineral matter, and of that matter which supplies nitrogen and ammonia. Here is the composition (pointing to a diagram,) of the different kinds of guano. The South American, it will be seen, contains, besides animal matter, ammonia and phosphate of lime, to the extent of 21 per cent., so that it is very rich. There are some varieties of guano, particularly one found at the Cape of Good Hope, containing 70 and even 80 per cent. of the phosphate of lime, the animal matter having disappeared by the action of the weather.

I pass on to the subject of mineral manures. Of these, first I shall speak of phosphate of lime. I showed you a certain form of mineral phosphate of lime, which was capable of being applied to the fertilizing of land. This phosphate of lime is brought in the form of bones, from abroad. These bones are boiled, crushed, and sold in the form of dust which is applied to land, and found to be exceedingly fertilizing. These bones contain about 33 per cent of animal matter or cartilage, which will burn away, or when boiled forms a glue, phosphate of lime and magnesia. These bones therefore are fertilizing, because of the animal, as well as mineral matter contained in them; hence they will raise good crops where mineral phosphates would not, for if the plant requires organic as well as mineral matter, these bones supply it. But if the soil is rich in the form of organic matter which supplies nitrogen, then mineral matter alone without the animal would be more suitable; but if the soil be poor in both, then bones are better than either animal or mineral matter alone. This is the explanation of the failures of a trial of phosphate alone, or of burnt bone alone, instead of the natural bone. Some have found one better than another, and persons who have found the mineral part to produce good effects, have assumed that, that is the only fertilizing substance in the bone—others, have found the converse to be true and the two classes are at loggerheads about it. But both are in fact, consistent with each other; for the bones contain two elements, both of which are necessary and valuable, and either of which, under certain circumstances will be found to be so. Bones are applied, not only in a crushed state, but in a fermented state, and on the principle that if the food of an animal must be in a state in which the animal can digest it, so if you put into the soil any substance on which the plant is to feed, it must be in a condition to be dissolved by

water, and thus capable of entering the roots of the plant. That this may be so, bones are boiled and applied to land, in that state, for it is found that a bone when crushed will remain for years in the land, apparently unchanged. In Manchester, bones are used in the manufacture of glue, which forms a sizing for fabrics. The bones thus boiled come out soft, full of water. They are then easily crushed and decompose easily when put into the soil. But to secure the easy dissolution of bones in the soil, fermentation has been introduced. The crushed bones, being mixed up with earth and allowed to ferment until the mass is reduced to a fine powder. This method is found greatly to facilitate the growth of crops. Thus a small quantity of the dust, goes farther than in the other form. But, there is one form in which bones are used with great profit—that is, when dissolved in sulphuric acid. The pulp is dried, sometimes mixed with gypsum, powdered and applied to the growth of turnips and with great effect. In England and Scotland, it is the only manure for the turnip. But these dissolved bones are applied as a top-dressing for wheat and other grain, and when strewed over the surface are found to be very effectual. I may mention one instance, where 600 weight of dissolved bones were applied to a crop of wheat and the product was raised from 29 to 53 bushels an acre. Farm yard manure applied under the same circumstances, raised the product to within 6 bushels of that amount per acre. This is an illustration of the superior effect of this bone manure. Bones are applied in this form to the grass lands of Cheshire, and with great profit. The lands there have been under dairy husbandry for many centuries. You will recollect, that the substances contained in milk when burned, are some of them, the very materials which the bones leave when burnt. The cow extracts them from the soil on which it feeds, and it appears again in the milk, as is found by analysis. This has been going on for centuries, and this continual drain of the soil, going on, it became impoverished. But the application of the bone, was found to produce remarkable effects in restoring the soil, though the principle was not understood. The explanation however, is found in the fact, that the milk and the bones, contained essentially the same substances, and that the latter restored to the soil, what had been taken from it by the animal. Here you see an illustration of the application of the knowledge acquired by the analysis of the bones and the milk, to practical husbandry. The discovery of the value of this kind of manure, applied to the grass lands of Cheshire, may be estimated from the fact that lands which once paid but 5 shillings an acre of rent, have been made to yield 40 shillings rent, besides a good profit to the dairy-

man. You see from this, how important it is to know the effects of certain kinds of husbandry upon land. Dairy husbandry produces a special exhaustion of the soil, and knowing this, and what substances have been taken out of the soil and carried off in the shape of milk, you know what to put in to reclaim it.

I have alluded to the circumstance that mineral phosphates are found in certain geological formations, and the mode in which they are employed, when dissolved in sulphuric acid, as a manure. This is manufactured and sold with us, under the name of super-phosphate of lime, and, as I have told you, it is made and used with great profit, both to the manufacturer and the farmer.

Among the other mineral manures, this consists only of phosphoric acid and lime; but among the mineral manures which supply the plant with all that it requires, I have a fourth class, of artificial mineral manures, which can be made by putting together the substances which the plant is found to contain. The tables which I have shown you exhibit, in the composition of different crops, the mineral matters which they take from the soil. I contrasted the exhaustion produced by the tobacco plant with that produced by wheat and barley. Now, to restore land by artificial manures, which has been specially exhausted by either of these crops, I must make up a manure which shall contain the substances which they take from the soil, and in like proportions; and thus, by especial manures, I can restore to the land exactly what the crops have removed; or if I want to vary the crops, I vary the composition of the manure accordingly. In this second edition of my Lectures, (exhibiting the book,) the first of which has been printed in this country, I have published a series of recipes, by which special manures may be compounded for all the crops we are in the habit of raising, and which have been made up from the results of experience and analysis, and which you will find worth your attention.

Experimental Agriculture is a branch now in its infancy; but what has been done has been sufficient to excite inquiry and induce experiments, with a view to determine the effect of this and that substance, when applied to this or that crop, under different circumstances. These recipes to which I allude have been tried, but not always with success, because not applied with care. Now, to make any advance in this department of knowledge, we must have experiments made in the field as accurately as in the laboratory. I have taken up this subject, and had just prepared, before I left home, a book on Experimental Agriculture, a volume of which has been sent me here. It is a history or review of the experiments which have been made, and the suggestions drawn from them, as to what should be done to open up this new field

of research. It is exceedingly interesting to find theoretical results practically exemplified and tested by actual experiment, as in the case I have mentioned of the application of bones to the grass lands of Cheshire. But after all, the result to which it is necessary to look, in these days, is that which shall enlist the largest number in favor of these researches, viz: the result which puts the most money in the pocket of the farmer. This is the point with reference to which experiments must be carried on. This will be the object of the succeeding volume of my book, in which the results of succeeding experiments will be given, in improving the condition of the soil.

I must pass over the application of lime as a manure, and several other matters connected with this subject. It is an interesting department of study. The subject of lime alone, of which I intended to speak, might form the subject of two or three very interesting lectures, but I cannot go into it.

Now you cannot fail to see from this course of lectures, the strictly scientific part of which I bring to a close this evening, that there is an exceedingly wide and extended application of science to the farmers' art, and that this is not merely theoretical, but has a positive and practical bearing upon the method by which the farmer may increase his crops and his profits. The four last lectures are more or less connected together, as the same chemical principles are comprehended in them all. You must have seen how closely connected are the different departments of the farmers' art, and how many beautiful relations subsist between that art and the connection of man with the earth on which he lives—the connection in fact, of all life, animal and vegetable, with the present state of things. You will recollect the interesting facts I have mentioned, showing the intimate connection between the circulation of the blood, and vegetable as well as animal life. You recollect the striking fact that the plant extracts the carbonic acid from the air and the animal destroys it, reconvertng it into carbonic acid and water. Suppose this cycle should cease, and that either the plant or the animal should not perform these functions, it is obvious that all animal and vegetable life must cease. But in the larger cycle, viz: that subsisting between the soil, the plant and the animal, it will have been seen that the interruption of the functions of either would destroy all vegetable and animal life. There is a still larger view of this subject, which comprehends the contemplation of the earth as one of a system of bodies revolving around the sun; the sun traversing space and the earth, and all the planets accompanying it. As a member of the system, it is of no consequence whether its surface is covered with animal or vege.

table life. All animal and vegetable life might cease upon this earth, and yet the earth continue its revolutions unchanged, and the system of the universe would not be affected. Gentlemen, we are not essential parts of the universe, but mere accessories, placed here at the will of the Almighty for purposes of his own, which we can, perhaps, in some degree fathom, and so far, it is our duty to follow them out. If the Deity has made all these things which adorn the earth, animal as well as vegetable, and above all has placed man as part of the system, I cannot help thinking, that it is His will that we should investigate them, and see if we can, why he has put them before our eyes and under our feet. These investigations furnish congenial employment for intelligent man, and result in substantial rewards. But among them none yield more substantial returns than those which belong to the intellectual cultivator of the soil, who studies nature in order to render the soil more fertile, and contribute to the happiness of the human family.

LECTURE NINTH.

MEANS BY WHICH GENERAL SCIENTIFIC KNOWLEDGE MAY BE DIFFUSED, AND
MADE AVAILABLE FOR THE IMPROVEMENT OF PRACTICAL AGRICULTURE,
AND THE GENERAL ELEVATION OF THE AGRICULTURAL CLASS.

GENTLEMEN :—I take it for granted, that you are all satisfied of the importance of scientific research to practical Agriculture. If satisfied of this, you must be also of the importance of diffusing a knowledge of the results of such researches, especially among practical farmers.

There are two objects we may have in view, in our desire to shed such knowledge. 1st. The improvement of the Agriculture of the State, or along with this, the elevation, intellectually and socially, of the agricultural community. All members of the community are interested in the first of these objects or ends, viz : the general improvement of the Agriculture of the State, and a large class are especially interested in the second, which looks to the elevation morally, intellectually and socially, of the agricultural community. In regard to the first of these objects, the general improvement of the Agriculture of the State, before we form any idea of what should be done, it is desirable to know what is the actual condition of Agriculture now. I must ask you to judge of the condition of Agriculture by the tests which I shall name. By the state of the roads in the agricultural districts ; the kind of rotation practised throughout the State ; the kind of stock reared, and the mode of feeding them ; the extent of land uncultivated, or poorly cultivated, compared with the density of the population.

You can only obtain accurate notions on this subject, by actual observation. I have not seen enough of your State, to form an opinion of its agricultural character ; nor have I any data from which to form an opinion, though I have heard and read much on the subject. But there is one mode we have within our reach, and of which I propose to speak, and that is, the average produce of the land. To a person unacquainted with the country, from personal observation, such data are generally very decisive indications of the state of its practical Agriculture ; at the same time, it is necessary to take into consideration with the average product, the physical geography of a country, its geological structure,

its climate, &c. ; but supposing him to know all this, he could form an accurate notion of the agricultural condition of a country from its products, and by comparing these with those of other countries. I have the average product of New-York, as shown by the last census, which is the best data I have. The average product per acre of this State, as so shown, is of wheat, 14 bushels ; of oats, 26 bushels ; of barley, 11 bushels ; of rye, $9\frac{1}{2}$ bushels, and of Indian corn, 25 bushels per acre. These results are given as the average product of the State, in one of the volumes of your Transactions. In one of the volumes of Prof. Emmons' Natural History of this State, I find another series of averages, a little less than these ; but I adopt the larger ones. Now, I believe there are few persons, acquainted with the early history of this State, who will not tell you that the average returns were formerly far greater than now. In fact, you may judge what the product of New-York once was, from the present product of New-Brunswick. According to returns, the average product of that country is of wheat, 19 bushels per acre ; of oats, 34 bushels ; of barley, 29 bushels ; of rye, 20 bushels ; of Indian corn, 41 bushels per acre.

Now, I can very well judge of the former product of New-York from these results obtained in New-Brunswick ; for, when I discoursed on the relations of Geology to Agriculture, I demonstrated, from the character of the soil of the two countries, as shown by the Geological Map, that, generally speaking, the western portion of New-York was naturally more fertile than a large portion of New-Brunswick, and therefore I conclude that the average product of New-Brunswick is far below what was formerly the case in New-York.

It may be interesting to you to present to you the average product of Ohio. In the northern part of Ohio, after a cultivation of 20 years, the average returns are scarcely half what they were when first settled, showing that the soil there is in the course of gradual exhaustion. The averages for the year 1848, which I find in the Transactions of the Agricultural Society of that State, are as follows : Of wheat, 15 bushels per acre ; barley, 24 ; oats, 33 ; rye, 16 ; Indian corn, 41.

You see, therefore, that in Ohio the condition of things is nearly the same, so far as wheat and oats are concerned, as in New-York ; barley and rye are greater, and corn much greater—many parts of that State being peculiarly favorable to the growth of Indian corn.

I have also here the average products of all the States ; but I see I have not put down the general average for the whole. It is enough, however, for our purpose to say, that the average product of this State

s about the average of Ohio, and that both States are sailing in the same boat; and that if you go on here in the same process of exhaustion, you will soon compete with that State.

Compare, for a moment, with these statistics, the crops in England. The average product there is, of wheat, 21 bushels. It is proper, however, to say here, that we have no statistics, and that this is altogether guess work. Our censuses give us no statistics of agricultural products; our farmers, also, are very jealous about giving information on these points; they have rents to pay, and they naturally think that if they give in large returns, they will have to pay larger rents; and that is one reason why we never have this data. Hence, the results I give you are but approximations. From the best information, the results are these: of wheat, 21 bushels per acre; oats, 35; barley, 32. That is all I can give you of the product of England. The averages of Scotland are these: wheat, 30 bushels per acre; oats, 46; barley, 40. These results are on the best quality of land.

I believe there is no reason to doubt that what has been produced in England and Scotland might be produced in New-York. I infer this, not only from comparing the character of both countries, but from the fact that the prize crops, annually competed for in your State, are larger than those given as the averages in England and Scotland. I have a table of the amount of premium crops in '46, and they range thus: wheat, 56 bushels an acre—that is the highest; Indian corn, 142 bushels—the average is only 25; oats, 106 bushels. This is all I have of the premium crops. Now, these are maximum results. I may state that in England we have crops of wheat as high as 88 bushels; of barley, 80 bushels; and of oats, 108. Indian corn we do not grow.

I regard this as certain, that if the climate and local circumstances are the same, what one soil will produce, science may enable another soil to produce; and that it is reasonable that the farmer who exercises a proper degree of skill in the culture of the soil, has a right to anticipate the same degree of success as has attended like efforts in other countries, having similar advantages of soil and climate. If certain parts of your country, which have a given geological character, will produce these large premium crops which I have mentioned, it is fair to presume that other parts of the State, having the same advantages of soil and climate, should produce the same results. This is the point which all interested in Agriculture hope for and desire, and wish you to aid them in attaining.

One point of view I might have pressed on you in regard to our Agriculture in Great Britain, and that is, that our farmers fancy they

suffer from the competition of the grain-growing districts of this country; they believe you can produce corn cheaper than they can; whether you can produce more from the same quantity of land, is another question. I do not think you can, but you are likely to be seriously affected by the competition of the Western States. You are therefore in a condition similar to, or approaching that of England, and you will have to compete with the rich virgin lands, though already somewhat exhausted, and you must do something to compete successfully.

In what way are you to compete successfully with those new and fertile regions? You can only do it by raising larger crops from the same quantity of land, without more labor, and of course at less cost. In the introduction of improved agricultural implements, which in England is a matter of very great interest, you have perhaps an advantage over the more remote States. But your object should be, to grow a larger quantity of grain on the same surface and at a less relative cost than before. In this way, we, in England hope to compete with New-York and the richest of the western prairies.

How is this to be done? Nothing can be done in this direction unless effort is stimulated by necessity. Hence, because the necessity with us at home, is great, we shall do something; and so here, as the necessity becomes greater, you will make more effort to compete with those districts, and when you do this, and not till then, will you be successful. How is this to be done? Those who possess the most knowledge will be sure to distance those who compete with them, if that knowledge be combined with prudence and discretion, for it is often thrown in the teeth of the scientific farmer, that those who have gone before him, have all failed. But the truth is, that those cases pointed at as illustrations of the unsuccessful results of scientific farming, have been generally those of mere enthusiasts, who had little practical knowledge, and who, along with science, did not apply that common sense with which prudent men always conduct their affairs. Knowledge must be applied to the improvement of the soil, if we hope to succeed. I think I have shown during these lectures, that we do possess the knowledge which is capable of growing larger crops at a cheaper rate. Now, if we possess this knowledge, it must be diffused to be applied; no matter what knowledge there may be in books, or in the heads of a few men, unless it be diffused among men who can apply that knowledge among the farmers, it is comparatively useless.

There are many ways of diffusing knowledge, and among these is the establishment of agricultural societies. The establishment of agricultural libraries, is another means of diffusing knowledge among far-

mers. Though in our country farmers are not generally reading men, still there always a few men in agricultural communities, everywhere, who do read, and are anxious to improve themselves in this branch of knowledge, and it is desirable in this view, that libraries containing agricultural works should be established. Their ideas and their knowledge, like a pillar of fire, become, as it were, centers, from which light radiates all around. Among us, there are organised farmers' clubs, in subordination to agricultural societies, where agricultural topics are discussed. We have also lectures occasionally, given sometimes in stated places, which are well attended, and by which knowledge is diffused. In the matter of agricultural periodicals, I do not think we have anything better than yours. Some of those published in this country are exceedingly good, and are well known in Europe. These are important instruments in the diffusion of sound knowledge on this subject. But I pass over all this, and come to the only other mode of diffusing this knowledge, and that is, by means of agricultural schools.

It is extraordinary, how little has been done for the diffusion of agricultural knowledge in this way—how long a time has elapsed in every country, before it has been found necessary to establish schools for this purpose. It is also remarkable what applause has been bestowed on those countries which first introduced this system, and who did the little that was done, during the last century, in that direction. What was done in Switzerland and Prussia, made a great noise at the time; but they did little after all. It is also remarkable that in those countries in Europe which have made the highest advancement in national education, how slowly they avail themselves of the means of instruction in this branch of knowledge. I hope and believe that the absence of those old habits and prejudices which so much restrain and retard the progress of such knowledge in Europe, will not retard its diffusion, among the more enlightened population of the New World.

But there are causes at work in the old world, which under all the efforts to diffuse agricultural knowledge, have retarded its diffusion by such means. We have schools for agricultural instruction, in all its grades; yet we find that in the neighborhood of these schools, not only is knowledge not diffused among the peasantry, but both they and the lands they cultivate, are in the most miserable condition possible. In my address at Syracuse, I alluded to some results in France and Bavaria, where in the latter particularly they have agricultural schools, model farms, agricultural societies, and agricultural instruction in the common schools, yet the Agriculture of Bavaria is of a grade among the lowest in all Germany. So in France where Agriculture is in a bad condition, there is an agricultural University, and there are central

agricultural schools in all the provinces. Instruction is also given to the peasantry in the communes. Therefore, though instruction in this branch of art is slow in being introduced, we are not to infer from the existence of schools in any country that Agriculture is in a flourishing condition there, nor are we to infer the contrary from the absence of these schools. In Scotland there does not exist a single agricultural school, yet its Agriculture is in a high state. In England, where ten years ago there were no such schools, Agriculture ranks next to that of Scotland. These instances, and those I have cited in France and Bavaria, show that the fact, that these schools exist in any country, affords no information as to the state of its Agriculture.

Hence in giving instruction in schools on agricultural subjects, experience in all countries that I have any knowledge of, shows that there are certain things to be attended to. First, it is necessary to avoid as far as possible the inculcation of organic changes in existing methods and institutions, you know how difficult it is to introduce anything new at all into our schools or seminaries. If you go for a great deal, you get nothing, if you ask only for a small portion of time, or give a little additional labor to the school master, requiring no new machinery to carry it out, then you are more likely to succeed, than if you at once demand, as some have, a large portion of the time, both of the pupil and the master in imparting new instruction. I do not know how far this caution may be necessary in this country, but as prudent men you would naturally adopt that course; as you would find that the introduction of such instruction would be more generally acceded to if you ask only what is necessary, and do not hurry on in advance of public sentiment.

To give you an idea of the manner in which this thing has been managed with us, I will state what provision has been made for agricultural instruction in Great Britain and Ireland. There are not many Agricultural schools in England, but there are a good many in Ireland. We have no special Agricultural schools in Scotland. In England and Ireland the principles of Agriculture were first introduced into the elementary schools. I say the principles, for you cannot expect to find a schoolmaster who can instruct his pupils in practical Agriculture. In general his education does not fit him for it, and it is therefore better in the elementary schools to undertake nothing beyond instruction in the principles of Agriculture. By principles, I mean those results to which scientific investigation has arrived; for instance, if I say that all substances which contain nitrogen in a certain state, are more or less useful to vegetation, that is a principle—a fact, which is the result of

experiment and research ; that is one principle. If, again, I say that all substances contain phosphate of lime, which forms a great part of the bones of animals, is capable of being useful to the growth of crops, I announce another principle, which is the result of a great many investigations. Thus I can state principles of this kind, which a boy can readily learn. It is such principles as these, that it is desirable to give in elementary schools, and when presented in brief terms, is never forgotten, and the boy when he goes out upon the farm recollects it ; he casts about for these substances, and if they are applied to the soil, he knows what the results will be ; for this is a procedure which is regulated altogether by a knowledge of principles. To fit the school master for teaching Agricultural principles, the study has been introduced into our normal schools in England, Scotland and Ireland, as a regular branch of instruction, and the school master now goes out able to give instruction, which will qualify the boy to become master of the principles in a short time.

So there are established in England in some of the grammar schools, and in some private academies, under the direction of individuals, agricultural departments, where instruction is given in the different branches of natural science bearing on Agriculture, and some knowledge also of practice obtained, not by a farm attached to the institution, but from the farms in the neighborhood. Within the last two years I established a school at Camelford, converting a grammar school into it. The farmers of the district, all around, open their farms to the inspection of the pupils, who availed themselves of the opportunity to view these farms at stated times, and observed all the processes going on, particularly in the labor also, and thus were enabled to get a practical knowledge of the subject, which very much facilitated the efforts of the master to explain the theory of what they saw going on around them.

We have also special agricultural schools in different parts of Ireland ; there they were established before they were in Great Britain. You know from the condition of Ireland, how desirable there a diffusion of such knowledge must be among the agricultural classes, and how important it must be to teach them how small farms may be made to yield great returns. These agricultural schools have been found to be productive of great benefits. The school of Temple Moyle has a large number of pupils, who are made to till the farm attached to it, thus applying practically the knowledge obtained in the school, and the result has been that the whole expense of maintaining the pupils, amounted to but eleven pounds a year each, or about fifty dollars, the farm pay-

ing all the rest of the expense of maintaining the institution, with the addition of some subscriptions raised in the locality. Now we have special agricultural schools established by a national board of education—they have introduced into them the little catechism of which I have before spoken, in which the principles of Agriculture are stated in a brief and clear manner. It is found that the boys never forget them, and are never at a loss how to apply them. They have also established district agricultural schools, and have made provision to fit teachers for them. A model farm has been attached to the normal school near. These are all schools established under the government in Ireland. We have no such schools in Great Britain established by the national board of education, but there too the study has been introduced in the common schools. But we have in England an agricultural college established within a few years. Six or eight years ago a school was projected at Cirencester, it had great difficulties to contend with at the outset, and one great difficulty was the apathy and indifference of the farmers themselves. Instruction was cheap there, but the farmers did not avail themselves of it. During the first years of its existence, out of forty pupils only eight were sons of farmers. But that state of things is fast disappearing, and a desire for this kind of knowledge has grown stronger. It has now about one hundred pupils, and the institution continues to flourish more and more every year.

Having given you this account of what we are doing in England and Ireland, you see that we have done little as yet, and that we have experienced little or no benefit from agricultural education; but we have come to a state, when we must, from necessity get this education, in order to compete with you.

You propose to do certain things here in New-York, and here allow me to make one or two remarks. It has been proposed to establish an Agricultural College. As to this I have no doubt whatever, that it is a proper measure to take; as it is proper in England, so it is in New-York. This should be done so soon as you are able to accomplish it—it is a right thing to aim at. The difficulty does not lie in establishing the institution, but in the details; you should be cautious that in the details you adopt no rash or hasty measures, but act with discretion and judgment. Your efforts should not be divided; you should set out with the determination to establish the college and nothing else—I mean nothing else in the way of establishing colleges. I have been asked whether I thought it would not be better to have six small colleges in different parts of the State. I had not studied the circumstances of the State, sufficiently to give advice on that point, but whatever these cir-

cumstances may be, or whatever the intention hereafter, you should not propose at the start to do more than establish *one college*, and direct all your efforts to get that in good working condition before you attempt another. If you fail in one you certainly would in twenty, if you succeed in one, you can then go on and establish more. It is of great consequence in reference to the character of the State and of the teachers, that you should have one good school first. If you were to establish thirty colleges in different counties of the State, I should like to know where you would get teachers to fill them? I do not think you will find in all America sound men of knowledge and discretion, who could be safely trusted to teach scientific Agriculture in thirty schools. I do not think they exist in the Union, much less in the State of New-York. You will act wisely and discreetly if you try to get one institution, it will be useful to your State, and will turn out men to fill up any other schools which you may afterwards establish.

Again, in any building which may be erected for this purpose, there should be provision only for what is likely to be wanted, instead of laying out money in erecting buildings to accommodate a large number of pupils, who have not come yet; you should begin by making room enough only for those who first come, and then you can add accommodations, as they are found to be necessary. One point I desire to impress upon you—excuse the liberty I take: you should not encourage the idea that any great and surprising results will spring out of this all at once. I have been myself the victim of extraordinary expectations. I have been attached to an institution in which persons were interested who had these high-wrought expectations of what was to result from it, and who almost supposed that one result would be, that gold would rise up, as it were, in the pockets of the farmers. These results not being realized, many concluded that science was really of no use in agricultural operations. If after the lapse of years you can, through this college, increase the average product of the State—if you can raise the average of wheat, alone, from fourteen to fifteen bushels per acre—I ask if this one additional bushel only, taking the State through, would not pay the cost of the college for ten years? If you can raise oats, from twenty-six to thirty-four bushels per acre, you will have accomplished a great result. But if you expect extraordinary results in a few years, either on the general agricultural character of the State or its farming population, you will be disappointed—not on account of the fault of the teacher, or of the system, but because your expectations were too high. As I have said, I have myself been the victim of such expectations; and I warn you not to stumble over the same stone. If,

after the lapse of years, you can raise the character of the agricultural community, so that a stranger, visiting your farms, finds the younger men possessed of greater intelligence than their fathers, and applying that knowledge intelligently in practice, so that the superior skill and science of the farmers of New-York are obvious, that will indeed be a proud thing for you to see, and for a foreigner to discover and acknowledge. But so great a result cannot be brought about in one year—it may take ten years. Again: it has been proposed to give instruction in scientific Agriculture, in the medical colleges of the State. All instruction in this branch of knowledge should be encouraged; no attempt should be made to put down such measures, if any are on foot. Medical men, passing from the college into a rural district, to practice their profession, cannot be less useful for having a knowledge of scientific Agriculture. Therefore, in medical schools, encouragement should be given to efforts to introduce this branch of study there. So in theological schools, the study should be encouraged. Clergymen may exercise a salutary influence upon husbandry, as upon good morals; but the great difficulty is, that the farmers will not send their sons to these colleges, and hence the rural schools are best adapted to the diffusion, (in the right quarter, and directly,) of agricultural knowledge. Besides, if they were to go to these colleges, they would be apt to learn unsound doctrine. It is not to be expected that men, however profound in one department of science, and whose habits of thought and study are all in that direction, should be familiar with practical Agriculture. Hence, they may take up crude notions and inculcate them, and do harm, rather than good, to the pupils under them.

It has also been proposed to attach agricultural departments to some of the colleges. To that there can be no objection; at the same time, any encouragement which the State may give to this kind of instruction, should be given to the one school by which all other schools will be regulated, when once you get it fairly organized. There is this difficulty in regard to attaching agricultural departments to existing colleges, that if this new department is under mere scientific men, the proper wants of farmers' sons will not be properly looked to. So sensible am I of this, that in the suggestions I made to the Legislature at New-Brunswick, as to the mode of improving its Agriculture, whilst I recommended an agricultural school at Fredericktown, where there is a college, I have recommended that it should not be connected with the college, because they are not practical men, and are not calculated to give instruction to pupils intended for practical life. What is true there, is true all over the world. It is necessary that such a school

should be in charge of men who understand Agriculture, and the wants and wishes of agriculturists, and who know what should be done to improve both.

I believe many persons look forward to the introduction of agricultural instruction into common schools, and I think it very important that this should not be lost sight of. In the lower grade of schools I think it most important, and it should commend itself to those having the affairs of the State in charge. The mass of your countrymen get their instruction in these schools. You reach a greater number by introducing this study into these schools, and you reach them at the least possible expense of money and time. You only ask the school master to give a little time to teaching one certain book, selected for its bearing on the principles only of Agriculture. To facilitate this instruction, I drew up this little catechism. It has been introduced extensively into the schools in Great Britain, and translated into every European language. But this obstacle has been found to exist, not only at home, but in other countries, and that is, the want of qualification or inclination on the part of the schoolmaster, to teach. In Scotland our schoolmasters are well educated men, but they are fixed and stationary, pursuing their vocations at one place generally all their lives, unless, as is rarely the case, some of the more skilful ones are transferred to places of greater emolument. These men find no difficulty in introducing this catechism. It has also been introduced into the schools in England, but there the grade of schoolmasters is lower. But we have there national schools for the education of teachers, the effect of which is, that a race of men are now coming out, who are capable of teaching this branch of knowledge. The same difficulty exists in Belgium and France, where their schoolmasters are not sufficiently instructed themselves to teach it. Of course this obstacle is only to be overcome by additional instruction to the schoolmasters, and it is a reproach to them, that they have so little application or capacity, that they cannot learn a catechism which a boy seven years old can perfectly understand. I examined a class of about a dozen boys, the eldest of whom was fourteen, the youngest seven years of age; the eldest got the first prize, the youngest the second. It cannot, therefore, be difficult for a schoolmaster to learn to teach these simple principles.

There is one obstacle, which in this State appears to me to be one of some difficulty—an obstacle to the introduction of this kind of study into the schools, and that arises from the unsettled condition of your teachers. You have not schoolmasters who permanently remain in one district; the trustees engage a teacher for a limited time, and then both

parties are at liberty to quit the engagement. In England they are fixed residents in the parish to which they belong. The difficulty here, is therefore, one of some moment. It precludes a unity of system, a concentration of effort in carrying it out, and it prevents the schoolmaster from taking that pride in the progress of his pupils, which he would have if he knew that a school was to be under his care for years, and he responsible for its management. This may stand in your way in introducing this study into your common schools, but it is not insurmountable, and you would do well to inquire how far it is practical to surmount it.

One or two observations as to the kind of instruction which should go into the schools, with a prospect of agricultural improvement. I have told you what branches of science tell on agricultural operations, and bring out principles applicable to the growing of crops, that the boy can learn in elementary schools; but in learning them, it is necessary to use scientific terms. Nitrogen, for instance, might puzzle a farmer; the boy, therefore, must understand this; he must be shown what it is. So with phosphate of lime; its nature must be explained to him, and after that, the boy will always attach the right signification to the word, understand your principles, and apply them intelligently. These two words belong to the chemical nomenclature; but in teaching these principles of which I have spoken, you do not teach Chemistry. If I tell the boy that rocks form the different soils, that is not teaching geology, but Agriculture. As to Chemistry, I do not object to its introduction into schools. I have devoted my life to the study of Chemistry, and it may well be supposed that I should not be averse to it. I am not. So with Geology; it is a study in which I feel a deep interest, but I do not recommend either on behalf of Agriculture. I recommend agricultural instruction, and Chemistry and Geology are only necessary to explain the terms used, in the elucidation of agricultural principles. At the same time, I have felt the difficulty of selecting what is necessary to teach, and what should be excluded from the list of studies. The chemist and the geologist teach their peculiar sciences. If they know at the same time the principles of practical Agriculture, then they know what it is necessary to teach, and what not. If you tell a boy any more than is necessary to enable him, for instance, to distinguish nitrogen from every thing else, you only confuse him. In this little book, the catechism to which I have referred, there are about twenty chemical words, which it is necessary to explain, and to do this, you must show the pupil what the substances are which these terms represent. Then he can follow you, and then he can understand all that is written in this book and the larger works. It is

only to this extent, that Chemistry and other sciences ought to be introduced into your common schools to teach Agriculture. I do not object to the introduction of Geology, Botany or Chemistry, but on behalf of Agriculture, I do ask for it. I only ask, and have asked everywhere, one hour a week during the last year of a boy's tuition, to impress upon his mind fully all the elementary principles of practical Agriculture; so that little is required to be taught in the elementary schools, and this little will produce good directly on the boy himself, and indirectly on the boy's father. It is remarkable how a man, who is most obstinate in resisting any new idea or process in regard to Agriculture when suggested by a grown up man, I say it is very remarkable, how readily he will listen to the same thing, coming from the mouth of his own son. The boy tells what he learns in the school to his father. The father is delighted at the wisdom of his own son, and he will allow his son to adopt in practice on his farm, what he will not listen to a moment, if suggested by a stranger and an adult. What is suggested by his son goes through his heart to his head, and that is the way to many people's heads.

My time is so far exhausted, that I cannot detain you with any further details. I will only make one other observation, and that is, that it is of great consequence that a farmer who owns a farm now, should make himself familiar with the best methods of improving the soil, in order to retain his position, for if he does not, another who has more skill, will drive him from his position, and take his place. As the son generally thinks as the father does, there is no appeal stronger to such men as are most unwilling to adopt new methods themselves, than that to a father on behalf of his child and his future prospects. This is true, as a general rule. I know that you have a strong desire that your sons should thrive in their professions, as parents generally have, that their sons should excel in their professions. This you can only do, by giving them more knowledge than you have; as much, at least, as the sons of others, bringing up their sons to different pursuits. I can make no stronger appeal to you, to exert yourselves, to take the proper steps to secure that knowledge, if not for yourselves, at least for those who are to follow you in the same profession. I cannot but think that you will say with the old man, who in a remote part of Scotland, attended one of my lectures, and drank in, open mouthed, all that I said, and who after I had concluded, came to me with tears in his eyes, and told me he was too old to learn all that, but he would like well to have his son learn it. I hope you will all participate in that feeling and see to it, that your sons shall not be ignorant of what concerns so nearly their prospects in life.

Professor JOHNSTON having concluded, Mr. PRENTICE, the President of the State Agricultural Society took the Chair, and Mr. B. P. JOHNSON was appointed Secretary.

Mr. BEEKMAN, of Columbia, remarked that Prof. JOHNSTON having now finished his course of lectures, it was due to him, as well as to the Society, that we should express an opinion as to the merits of these lectures, and to test the sense of the Society, he begged leave to offer a resolution, which he read, as follows :

Resolved, That we have listened with great interest, as well as profit, to the very instructive course of lectures delivered by Prof. JOHNSTON, on "The General Relations of Science to Practical Agriculture ;" and that we take great pleasure in expressing our united approbation of the great practical value of his lectures to the practical farmer, as well as to the man of science.

Dr. BEEKMAN said he had another resolution in relation to the volume which Professor JOHNSTON had exhibited to us, being the second edition of his lectures on Agricultural Chemistry and Geology, presenting the results of scientific research adapted to practical Agriculture, which he begged leave to offer for the consideration of the Society. It was as follows:

Resolved, That as the principles advanced in the lectures which have been delivered, are more fully developed in the second edition of Prof. JOHNSTON's lectures on Agricultural Chemistry and Geology, we would respectfully request him, if consistent with his engagements, to prepare an edition for re-publication in this country.

Mr. Baldwin of Syracuse, said he rose to second the resolutions offered by the gentleman from Columbia ; and in doing so, begged leave to submit a few remarks.

When we contemplate, said Mr. B., the elevated position which the learned Professor occupies in his own country, standing as he does at the head of a profession which he so much adorns ; when we consider how extended, broad and profitable to himself as well as to others is the field of his labors—and how great have been the sacrifices pecuniary and otherwise, which he has made in accepting the invitation of our Society, to deliver its annual address last autumn, and in remaining here, and in this vicinity since that time, to deliver the course of lectures which have just now closed, and to which we have listened with so much profit and delight—and especially, when we reflect upon the *character* of those lectures—the beautiful manner in which they have opened to us the great volume of nature, giving us a glance at its hid-

den mysteries and treasures—showing us the properties of the earth and the soils, the connection and relation between the earth and the vegetable kingdom, and the connection and relation between that kingdom and the animal creation, with the means of improving each; and, by the knowledge thus imparted, provoked an appetite for more, and leading us by that knowledge, from nature up to nature's God, and thereby making us not only better agriculturists, but better men, better citizens, and better christians; in view, sir, of these multiplied and high considerations, I am sure that I but express a common sentiment when I say that we sincerely thank our friend, the learned professor.

And, Mr. President, said Mr. B., if these lectures shall have as we trust in heaven they may, the effect of awakening our Legislators to a proper sense of their duty in regard to this great interest, and which shall lead them fairly and fully to respond to the recommendations of his Excellency the Governor in his late message—to respond to the recommendations of the Agricultural Commissioners in their late and able report on the subject of an Agricultural College and Experimental Farm—to respond fairly and fully to the united voice of their constituency, how deep and enduring will be that obligation and our gratitude.

And sir, said Mr. B., why should they not thus respond? Have not all the other great interests of the State found protection at their hands, while this, the parent of them all, has been lost sight of and neglected. Is there any other interest in the State greater than this? And why should this alone be left without protection?

By the lecture which has just now closed, you have learned that the farming interests in this State are in process of deterioration; that the average of all crops is continually diminishing; the tables of the products, exhibited by the learned Professor, show this; and he also shows us the means by which these products may be increased—by which we may be brought back to the products of a virgin soil.

¶ The learned Professor in his lecture this evening has also referred us to the products of the fertile soils of our new States, the prairies of the boundless west, and which are brought into direct competition with the products of the soil of this State, and by which it appears most evident that we cannot much longer sustain ourselves against this powerful competition. What then, sir, is to be done? Why, sir, there is but one thing that *can* be done, and that is, to improve our system of Agriculture, and by that system to increase the quantity as well as the quality of our agricultural products. The lights of experience and of science will enable us to do this. But a knowledge of that experience

and science must be acquired, and how can it be so well acquired as at an institution established for that purpose.

It is true that reference has been made by the learned professor to the agricultural schools of Bavaria, Prussia and other countries in Europe; but it occurred to him at the time, as he doubted not it did to them, that as between the people of those countries and our own, there was no analogy whatever. Their governments were different. They were oppressed subjects; were vassals and serfs, while we were freemen; they were ignorant—we enlightened. There the masses are uneducated, while here education like the light and dews of heaven, under our common school system, descends as it should descend, alike and equally upon all. Our farmers as a class are intelligent and educated men. But few of the farmers of those countries own the soil they cultivate, while ours, not only own it in fee, but are emphatically the lords of the soil. Even in England, the learned professor has told us, that the farmers as a class were not reading men. How different the case with us. Ours *are* reading men. Where is the farmer in this State that does not at least take his newspaper? Look, sir, at the one hundred thousand subscribers and readers of various agricultural periodicals of the State, and it will be seen that there is not the slightest analogy between the old world and the new in this respect.

Sir, continued Mr. B., the farmers of New-York are not only ready for, but they demand this measure—the ground is already prepared—the loaf is already leavened; for eighteen years at least it has been at work, and what are its fruits? Look, sir, to the general interest awakened on this subject, look to the immense gatherings at your annual fairs, look to the improved condition of stock and agricultural implements; and above all, sir, to the increased circulation of agricultural papers and books, and you will agree with me, sir, that the time *has* come; that the harvest is ripe; and the sickles are ready and only wait the bidding of the law-making power, to commence the work. Yes, sir, the time *has* come when the farmers of New-York, in view of the almost overwhelming competition of the west, are called upon to look at home—to protect their own interests. And how, sir, I repeat, is that interest to be protected, except by the introduction into it of the lights of experience and science? We have this evening been taught by the learned Professor, how one acre can be multiplied into four acres; or, in other words, how one acre can, by an improved system of Agriculture, be made to yield as much as under our present system, four produce.

Now, sir, suppose a proposition were to be submitted to this Legislature, by which the agricultural wealth of the State, for an outlay of a

few thousand dollars, could be doubled, does any one doubt that such proposition would at once be seized upon and adopted by that honorable body? Surely not; and yet for a comparatively small outlay, by adopting the system proposed, that wealth may not only be doubled, but quadrupled. And will not the Legislature adopt it; will they not give us an institution where the farmer's boy may be educated—where he may receive in reference to his calling, such an education as all other classes in this community receive in reference to theirs? In a word, will it longer allow this numerous and highly respectable class of our fellow citizens to be neglected; will the Legislature longer allow this great interest, which lies at the foundation of all others, to suffer for the want of that aid which it, and the united voice of an impatient constituency so loudly and imperiously demand? I trust not, sir. I trust, said Mr. B., that the Legislature will not only give us an Agricultural College and Experimental Farm, but that it will endow it with such ample funds, as to place it upon a strong and permanent basis, a basis which shall alike perpetuate throughout all time to come, the wisdom of this Legislature and the liberality of the State.

Mr. B. begged pardon for trespassing so long upon the attention of the house, but he could not have said less, either in reference to his friend, the learned Professor, or of the great and interesting subject now before the Legislature, without doing violence to his own feelings; and he therefore hoped that he might be excused for the time which he had occupied.

Mr. B. said he must also crave the indulgence of the house for a moment, while he considered the second resolution offered by the gentleman from Columbia. That resolution, sir, proposes to reprint in this country a valuable work of Professor Johnston on the subject of Agriculture and its kindred sciences. I have not, said Mr. B., read the whole of that work, but from the examination which I have given it, I am satisfied that it will make a valuable addition to our agricultural libraries; indeed, such is its character that I am of the opinion that any man who will make himself familiar with its contents, will become a scientific farmer. But the English edition was too expensive for general circulation; he hoped, therefore, that a cheap American edition might be issued, and that it might be found, as he had no doubt it would be, on the shelf of every intelligent farmer of the State. And, in conclusion, he desired that both resolutions might be adopted.

At the close of Mr. B's. remarks, the resolutions were unanimously adopted, and then the Society adjourned.

B. P. JOHNSON, *Secretary.*

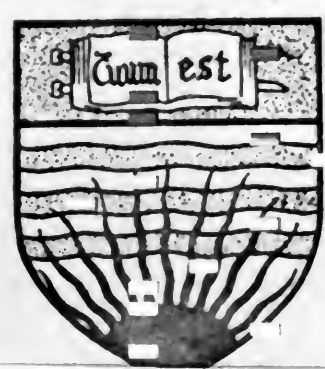
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