of the manure as a dressing for an acre of ground, there is evidently a quantity of solid manure annually poured into the river equal to fertilizing more than 50,000 acres of the poorest cultivated land! The quantity of food thus lost to the country by this heedless waste of manure is enormous; for only allowing one crop of wheat to be raised on these 50,000 acres that would be equal to the maintenance (calculating upon an average produce of three quarters of wheat per acre) of 150,000 persons. London, too, is only one huge instance of this thoughtless waste of the agricultural riches of the soil of England. From every other English city, every town, every hamlet, is hourly passing into the sea a proportionate waste of liquid manure; and I have only spoken of the solid or mechanically suspended matters of the average; the absolutely fluid portion is still rich in urine, ammoniacal salts, soda, &c."

The earth is surrounded by water in a state of vapor, and the quantity varies according to the temperature of the atmosphere and other circumstances. Verner found as a mean of fifty experiments, in 1,000 parts of air, 8.47 parts of vapor. In the forenoon, and before two o'clock, the mean was 7.97; and between two p. m. and evening, 8.85. There is more humidity in the atmosphere during the day than at night; and more during the summer than winter; more in low flat countries than in mountainous regions; and less in the interior of continents far removed from rivers, lakes, or the ocean. A slight change in the temperature of an atmosphere, saturated with humidity, produces fogs, clouds, and rains; and by congelation, snow, &c. A continuous evaporation takes place from the ocean, lakes, rivers, and the soil, and a return to the earth in form of dew and rain. The amount of evaporation that takes place in a country is greatly influenced by the operations of the farmer. In a report made by Andrew Brown and Dr. M. W. Dickeson to the American Association, in 1849, those gentlemen remark "that the annual quantity of rain that falls in the valley of the Mississippi may be estimated at 169,128,960,000,000 cubic feet, which is about $11\frac{3}{8}$, or 11.3636, times the quantity which is discharged by the river. There can be but two ways by which this immense quantity of water can make its escape from the valley; one is by the course of the river, and the other by evaporation; $\frac{8}{91}$ parts are carried off by the river and $\frac{83}{91}$ parts by evaporation. Thus, we arrive at a fact of the most momentous importance to the planting interests of Louisiana and Mississippi; for it will be at once perceived that the more exhalations are promoted, the less liable will the low or bottom lands of these two States be to the periodical inundations by the river.

"If it be asked by what process it is expected that evaporation can be promoted over such an extensive area as the Mississippi valley, so as visibly and permanently to affect the planting interests of the above-named States; the answer will be found in the fact that the process has been, and is now, in the most rapid and successful progress, and of that kind which is the best calculated to produce so desirable a result, viz: the clearing of such large portions of the valley of its forests for the promotion of agriculture, and the consequent exposure of the lands to the action of the sun and winds, the very best promotors of the evaporating process, particularly on a large scale.

"So rapid is the progress of this increased exposure and its consequent evaporating tendency, and so visible have been its effects on the Mississippi river, that we may hazard the assertion with safety, that there is not now by twenty-five per cent. as much water passing down the Mississippi as there was twenty-five years ago; for at and prior to that time, there were annual inundations of many feet, and long periods of submergence of almost all the bottom lands, from the bluffs on one side of the river bottom to those on the other side. Such lands were at that period accounted valueless, and to such a degree that but little or no hopes were entertained of the practicability of their redemption by any artificial means—that is on any general scale; but such has been the diminution in the annual quantity of water discharged from the valley, that those lands have been progressively and rapidly redeemed from overflow, until very great portions of them are now in the highest state of cultivation, and with but slight assistance from art in the way of embankments, and these such as could not have been at all available against the overwhelming effects of floods and the length of time of their continuance; for then there were annual inundations, both deep and expansive, of the waters, over almost all the bottom lands, but now the river seldom rises to the same elevation as formerly, and, when it does, it is of much shorter duration, and the waters are almost exclusively confined to the channel of the river, in place of being spread over almost all the bottom lands the whole spring and early part of the summer."

Such changes are progressing, generally unsuspected and overlooked, but not the less sure.

The art of producing large crops by means of artificial supplies of water, has been practised from remote ages in the warm countries of the world. It was used by the aborigines of America, by the Incas, the inhabitants of Mexico, extensively practised by the Egyptians, the Romans, and at the present day in France and Germany. The Hindoos make no attempt at cultivation without artificial irrigation. The rivers of Italy are made subservient to agricultural wants wherever it is practicable. Arthur Young gives an account of an hour's run of water through a gutter, near Turin, which produced, in 1778, 1,500 livres. The rent of irrigated lands in Italy is much larger than upon land not watered. Moses, in speaking to the Israelites in the wilderness, said: "The land whither thou goest in to possess it, is not as the land of Egypt, whence ye came out, where thou sowedst thy seed, and wateredst with thy foot, as a garden of herbs." Here the lawgiver alludes to the machines that were used in Egypt, which they worked with their feet, for raising water. Virgil tells how to bring down the waters of a rivulet upon the sown corn, and when suffering from heat, to convey the vivifying liquid from the crown of the declivity, in channels, to the roots of the plants. Columella, Pliny, Cato, Varro,* &c., all dwell upon the importance of irrigation. It is found profitable in England to irrigate plantations of willows and other semi-aquatic trees upon dry soils. The efficiency of irrigation is

* Sine aqua omnis agricultura est miserabilis et sine effectu.—*Varro, d. r. r.*

dependent upon many considerations; one of the principal is the nature of the subsoil. When it is a tenacious clay, the preparation consists in suitable under-draining, that would be useless where the subsoil is sand or open gravel.

Some waters are injurious. Certain salts of iron are known to be unfavorable to vegetation. Waters issuing from factories impregnated with animal and vegetable substances, such as the waters of distilleries, breweries, slaughter-houses, &c., are highly fertilizing; others issuing from chemical establishments, calico printing factories, are injurious. Salt water in small quantities may be found useful upon certain plants, such as the grasses, asparagus, &c., while they are positively injurious to such plants as rice. The salt marshes of France are known to produce a superior quality of mutton, which commands a high price, and is known in the French market under the name of "pres salé."

Waters impregnated with carbonate and sulphate of lime are very fertilizing. In certain parts of Germany, a weak solution of sulphuric acid has been employed for irrigating grass lands with great advantage. Those which hold in suspension mud and other detritus, are highly useful, particularly on sandy soils; the fine mud settles in the pores, and gives consistency, but any soil would be benefited by water holding mud in suspension, and that, of course, in proportion to the amount of organic and saline matter in the mud.

Sir Humphrey Davy thought that the protection of grasses from frost during the winter season was of great importance, for a meadow irrigated in winter is preserved from sudden alternations, and from the effect of the roots being thrown out of the ground by alternate freezings and thawings. The water immediately in contact with the roots of the grass is rarely below 40° Fahrenheit. In the month of March, in a meadow near Hungerford, the air was, at 7 o'clock, A. M., at 29°. The water was frozen above the grass, and the temperature of the soil below the water in which the roots were growing was 43°. While the temperature is thus prevented from falling during the winter, it is kept cool during the summer.

Irrigation supposes water in motion; if it be allowed to stand and stagnate, its effects would destroy the objects sought to be accomplished. Instead of fine grasses we would have a growth of carices, junci, and other coarse plants of no value.

Sir John Sinclair says that the advantages of meadow irrigation are chiefly as follows:

First. With the exception of warping, it is by far the easiest, cheapest, and most certain mode of improving poor land, particularly if it is of a dry and gravelly nature.

Second. Land once improved by irrigation, is put into a state of perpetual fertility, without any occasion for manure or trouble of weeding or any other material expense.

Third. It becomes so productive as to yield the largest bulk of hay, beside abundance of the very best support for ewes and lambs in the spring, and for cows and other cattle in the autumn of every year.

Fourth. In favorable situations, it produces very early grass in the spring, when it is doubly valuable.

Fifth. Not only is the land thus rendered fertile without having any occasion for manure, but it produces food for animals, which is converted into manure, to be used on other lands, thus augmenting, in a compound proportion, that great source of fertility.

The subject of irrigation is one of immense importance, in a dry, arid climate, such as characterizes portions of the western plains particularly. It is paramount, and may be employed throughout the continent with advantages greater than any other agricultural application. It is an important art of itself, and one that requires special acquirements for its adaptation.*

The direct action of the fertilizing constituents of water are not the only influences which that substance exerts upon our fields and growing crops. Its simple percolation through a soil has an important influence, by displacing gases and thus creating circulation of air and bringing a fresh supply of ameliorating agents.

A little reflection will teach us how to prevent the disastrous consequences of the sudden and powerful rains that fall in our climate. If the ground is cultivated shallow, we must suffer from washing. A hill-side plowed two or three inches would meet with the same fate that we would expect if we were to expose an inclined looking-glass, upon which we had sprinkled sand. The deeper a soil is stirred the better rain will be absorbed, instead of running off; and the deeper the furrow the longer will the moisture be retained. The alternate influence of showers and sunshine upon deeply-stirred land brings about another important effect, which cannot be obtained without it: we allude to aeration, an influence of great importance, by which not only the organic portions of the soil are, by aid of air circulation, brought into a state of decomposition; gases are evolved, new combinations formed, the inert mineral constituents are also decomposed, new salts are created, and numerous chemical actions take place, producing active food for plant-life.

It is, of course, necessary to distinguish between a wholesome humidity and destructive saturation; while the one is to be cherished, the other must be avoided. On the subject of under-draining we shall not enter; its importance is too great for a cursory notice in a paper of this kind, and we refer our readers to the many valuable publications written upon the subject.

Liebig makes the following beautiful remarks:

"There is not to be found in chemistry a more wonderful phenomenon, and which more confounds all human wisdom, than is presented by the soil of a garden or field.

"By the simplest experiment, any one may satisfy himself that rain-water, filtered through field or garden soil, does not dissolve out a trace of potash, ammonia, silicic, or phosphoric acid. The soil does not give up to the water one particle of the food of plants which it contains. The most continuous rain cannot remove from the field, except mechanically, any of the constituent elements of its fertility. The soil not only retains firmly all the food of plants which is actually in it, but its power to preserve all that may be useful to them extends much further. If rain, or rather water, holding in solution ammonia,

*See Stephens's Practical Irrigator, Smith's Observations on Irrigation, Brown's Treatise on Irrigation, Sir John Sinclair's Code of Agriculture, Voyage en Espagne, par M. Jaubert de Passa, Anleitung zum praktischen Ackerbau von Schwerz, Lr 1 potash, phosphoric, and silicic acids, be brought in contact with the soil, these substances disappear almost immediately from the solution. The soil withdraws them from the water. Only such substances are completely withdrawn by the soil as are indispensable articles of food for plants. All others remain wholly or in part in solution."

In connection with this interesting subject, it may be remarked that the absorbent power of soils varies according to their composition. It is greater in clays than those which are silicious or sandy, but belongs to all, more or less, not excepting those of a calcareous nature. Liebig tells us that if the phosphate of lime be dissolved in weak carbonic acid water, and the solution filtered through a soil, the phosphate of lime is removed from solution, and the same result takes place with the phosphate of magnesia and ammonia. This is a fact of great agricultural importance, from the constant occurrence of those substances in organic manures.

The complete absorption of potash, ammonia, and phosphoric acid by the soil, and thus entering into combination and forming insoluble compounds, would appear to militate against the received opinion, viz: that plant food must necessarily be in a soluble state for assimilation. This is contradicted by the above facts. It is, besides, well known that plant vitality has the power, as it were, of corroding insoluble substances, and absorbing them by the roots. Varieties of plants growing upon rocks contain large quantities of the substance of which the rock is composed. Such is known to be the case with lichens growing on calcareous rocks. Again, the roots of the grape-vine have been found surrounding, and its rootlets insinuated in every manner through, around, and enveloping a piece of bone, which finally disappears. Nor does it seem that assimilable food should necessarily be soluble, provided it be in a state of atomic division.

It has been stated that the constituents of plants are divided into two classes, organic and inorganic. The first named are derived from water, carbonic acid, nitric acid, and ammonia, and may come from the air through the leaves, or from the soil through the roots. The inorganic constituents are of a different character, and can only be received from the soil and through the roots. It then becomes important that there should be deep preparation of the soil, in order to commingle the surface with that which underlies, that the roots in their search for food (for it is proved that it does not circulate in the soil as it becomes fixed by combination) may more readily come in contact with all the substances the plant requires to form the wonderful compound necessary to its growth and development. Deep preparation insures aeration, and the decomposition of the constituents of the soil is thus attained by the action of the atmospheric agents. Both carbonic and nitric acid, which are known to exist in the air and water, have a powerful action upon the soil, but unfortunately our knowledge upon that subject leaves much to be desired. The importance of minute division of the soil, and the manures which may be added, must, on reflection, be evident to every one. Plants assimilate food in a state of atomic division, and the nearer we approach that point the better; beside which, they will more readily undergo those chemical changes which are ever taking place in Nature's great laboratory, the earth.

By breaking the clods mechanically, by exposure to the air, and the freezing effects of water, the mass is pulverized, and thus food, before locked up, is approached and used by the tender roots of the plant.

"Plants cannot obtain from the soil more food than it contains. Further, its fertility is not to be measured by the whole quantity present in it, but only by that portion of the whole quantity which exists in the smallest particles of soil, for it is with such portions alone that the rootlets can come into close contact.

"A piece of bone weighing one ounce, in a cubic foot of earth, produces no marked effect on its fertility. But if this one ounce of phosphate of lime be uniformly distributed throughout the earth, it will suffice for the nourishment of one hundred and twenty wheat plants.

"Of two fields with the same amount of food, one may be very fertile, and the other very unfruitful, if the food is more uniformly distributed throughout the former than the latter. The common plow breaks and turns up the soil without mixing it. It only displaces, to a certain extent, the spots on which plants have already grown, but the spade breaks, turns, and mixes it thoroughly."*

Those plants which reach maturity in a short time are materially affected by the preparation of the soil. Their powers of absorption are much greater in the spring than in the summer, when the leaves are being formed, and when the plant is in the full vigor of growth, than when it has reached its maturity. We have a familiar instance of the importance of preparation in our corn crop, and the stimulus that is imparted to it by constant working, by which food is continually renewed and brought into close contact with the roots, and the soil kept in a well pulverized state, thus increasing its absorbing powers. The descent of water through the soil, and its escape upward as vapor, tend to the same end, and hence the great importance of under-draining.

Chemists employ sulphuric acid in their experiments for absorbing moisture. Lime and caustic potash are also used. Soils possess the absorbent power in an eminent degree, and it is by that inherent quality that plants are enabled to resist extreme droughts. The power of absorption depends greatly upon division, color, &c. A dark soil absorbs heat more readily than a light-colored one; it also radiates heat quicker. When the sun sets, the earth begins to radiate; in proportion as it cools, will be the amount of dew deposited. When a gas passes to a liquid state, caloric is evolved; such is also the effect when a liquid passes to a solid. The reverse occurs when a solid becomes liquid, or a liquid a gas. By the condensation of vapor, or the formation of dew, heat is evolved; by the absorption of dew, a further degree of sensible heat is produced. This process prevents a too sudden change of temperature in the surface of the earth, and which otherwise would have been sensibly affected by the too great radiation of heat. This equalization is brought about in a manner to excite our admiration. Evaporation is far more rapid in a dry, than in a moist, atmosphere, and more rapid in a current of air than when it is still or stagnant. Dry, porous, and thoroughly-pulverized soils radiate heat

* Liebig's Letters on Modern Agriculture, p. 108.

from a vastly greater number of points than wet and compact soils, and receive more abundant depositions of dew. Sands are powerful absorbents, and some countries depend almost wholly upon this for the support of vegetation. The sandy plains of Chili seldom receive any rain, yet, in consequence of their excessive radiation of heat and the heavy dews at night, they maintain a high fertility. If a soil be sufficiently permeable to the air, condensation may take place below during the day, at the same time that the surface may be giving off both heat and moisture, which is due to the relative degree of heat between the two.

To the farmer and the gardener, the soil is that portion of the earth's surface or crust which supports vegetation, or that is susceptible of cultivation, and is rich or poor accordingly as it is well or illy adapted to production. Soils are formed from the decomposition and disintegration of rocks, and are either from those immediately underlying, or may have been brought from a distance by causes still acting, or that have ceased to operate. The tendency of all high land to depression, and the consequent elevation of low grounds, is a never ceasing action upon the surface of the earth; winds and tides, currents and volcanic perturbations, elevations, the depressions and ejectments, continuous action of the atmospheric agents, changes of temperature, moisture, &c., and those causes acting from eternity, have caused the present state of the surface of the earth. But the soil contains more or less of plant and animal life, or the result of their decomposition. Traces of obscure microscopic life first manifest themselves; these objects live, assimilate food, procreate, and die. From their remains other and a higher order of organisms appear; they run their course and disappear, and their substance is by gradation finally transformed into the bone and muscle of man.

The soil has a varied composition, according to locality and circumstance. The decomposition or disintegration of an argillaceous rock would naturally give rise to a soil in which aluminous properties would preponderate. If the soil originated from a silicious rock, then it would be sandy; if from limestone, we should expect it to be calcareous. These and other substances, variously intermixed with organic matters in different states and stages of decomposition, form soils. They owe their properties to the distinctive minerals from which they are derived.

These inorganic constituents do not exist in the atmosphere, and are supplied by the earth, as they do not grow; and having been created once and forever, it follows that, if removed, they must be replaced. It does not matter how removed, whether in the form of grass, grain, milk, flesh, or bone, if taken away they are gone, so far as the farmer is concerned. This principle lies at the foundation of all successful agriculture, and is the fundamental axiom for which Liebig and others have so long, so laborio isly, and ably contended.

It would be as ridicul.)us for the miner to suppose that his exhausted placer would yield as much gold by re-working, as for the farmer to think that his exhausted lands would be recuperated without the addition of the substances extracted from it.

All the constituents of soil are compounds: they are oxydes of some metallic base, the organic portions are animal and vegetable substances in a decomposing state, complex and passing by degrees to simple forms. Soils, then, in complexion and composition vary. Two soils originating from the same rock may differ widely, in consequence of mechanical condition, subsoil, situation, climate, and cultivation. But as rocks are the same in all parts of the world, so must they give rise to a similarity of soil. In one hundred and forty-six soils analyzed by the geological surveyor of Massachusetts, taken from every variety of rock formation, the most remarkable uniformity was presented. These again, as compared with forty-eight soils from Germany, Holland, Belgium, Hungary, and Bohemia, offer the same striking uniformity, differing but slightly from American soils.* These facts would appear to show that there is not only a great similarity, but that their composition is independent of the variety of rocks which they overlie. Some of the most fertile are those formed by deposits, and the amount of fertilizing material carried from one spot to another, or entirely lost in the ocean, defies any estimate. Drs. Dickeson and Brown estimate the annual deposit from the Mississippi river to amount to the enormous quantity of 28,188,053,892⅙ cubic feet of solid matter. That amount is independent of the coarse sand and gravel transported by the river current, which they were unable to estimate.

Mr. Leonard Horner estimates that "the Rhine carries down every year 1,973,433 cubic yards of earth, and if this process has been going on at the same rate for the last two thousand years, and there is no evidence that the river has undergone any material change during that period, then the Rhine must in that time have carried down materials sufficient to form a stratum of stone a yard thick, extending over an area more than thirty-six miles square."

From the nature of the constituents of silt, and the finely comminuted state in which it is deposited, we should expect it to be fertile; and so long as the deposits continue, so long will their richness remain. Such soils are among the richest known. The low grounds bordering on the Nile, the Mississippi, the Rhone, the Danube, the Po, the Wolga, Orinoco, &c., are examples, and maintain their fertility without apparent diminution. The composition of alluvium depends upon the geological formations and the character of the country through which the waters pass; and the nature of the deposit again depends upon the current. If the stream be sluggish, the particles are much finer than if the water be rapid or turbulent. When the uplands of our country have been impoverished by successive croppings or injudicious tillage, the low grounds will resist longer, and continue to be a resource. But the amount of low ground is insufficient to supply the requirements of a dense population; hence the necessity of fertilizers. Organic manures, those of a nitrogenous nature, have been used from time immemorial. It is said "that the barn-yard yields a panacea for all the farmer's ills." This is not rigorously correct; for there are soils which never can be rendered fertile by the application of barn-yard manure, but which may be improved by correctives, and the addition of organic substances.

* Dana's Muck Manual.