of seed, so far as their mineral constituents have yet been examined, for the proportion of magnesia exceeds that of lime, in approximative round numbers, two to one in peas, beans, vetches, quince, buckwheat, linseed, &c.; two and a half or three to one in wheat, rye, oats, coffee, &c.; six or eight to one in maize, millet, and in the seeds of pines, firs, &c.

On the other hand, the opposite condition occurs regularly in the leaves and stems of plants, and in the wood of trees, in which lime has always the superiority over magnesia, and exists in two to eight times greater quantity, whence he deduces the law, that magnesia is especially necessary for the maturation of the seed, and lime for the development of the herbaceous and woody structure.* Lampadius also thinks this substance particularly favorable for the production of rye.

We have dwelt upon this subject, because much injury has been caused to agriculture by the prevalent opinion that the presence of magnesia in limestone, when calcined and applied to land, was followed by bad consequences. Much has been written to explain the cause of this, as we consider it, imaginary evil. Caustic magnesia, or magnesia without carbonic acid, may absorb carbonic acid much more slowly than lime, and in the presence of the latter substance, it will not combine, until the lime has been saturated; yet after all that has been stated, it would appear less than probable, that the presence of caustic magnesia should play so unfavorable a part, and so contrary to experience.

The salts of magnesia may be employed, as the salts of lime, for fixing ammonia, but in that case its application will depend upon its cost. When a salt of that base is added to urine, it produces a precipitate of the phosphate of magnesia and ammonia. Caustic lime, containing magnesia, is used for this purpose; but owing to the bulk of lime, the amount is rendered less portable. The phosphates of magnesia and ammonia, when applied at the rate of one hundred and thirty to two hundred and sixty pounds per acre, had a powerful effect upon the production of Indian corn; at the rate of three hundred weight per acre, it increased the crop of grain six times, and of straw three times.†

Magnesia is a constant and important constituent of sea-water. It is also found in many mineral waters, and to this fact their virtues are attributed. As it usually exists in the ashes of cultivated plants, its presence in the soil is a requisite to fertility, and its addition of manifest necessity wherever it may be wanting.

PHOSPHORUS.

Of the substances with which the farmer has to do we think phosphorus the most important. It is found in all animals and vegetables; without it neither the one nor the other could live. It is detected, if not pure, as has been stated frequently, in combination with a particular organic substance, in the brain, the spinal marrow, the spermatic liquid, in the melt of fishes, certain mollusca, &c. It is also diffused very widely, and is discovered in combination with oxygen in all rocks, in all soils, and

* Stöckhardt's Agricultural Chemistry.
† Johnston's Agricultural Chemistry.

in the flesh, bones, &c., of fish, reptiles, insects, birds, animals, and their secretions. Some of the fossil excrements of extinct animals are extensively and advantageously used as fertilizers. Wherever there are organisms, either vegetable or animal, or their remains, it is very strong evidence of the presence of phosphoric acid. It is detected in almost all limestone rocks, and particularly in those containing fossil remains. Close investigations show its presence in the older crystaline rocks; and where it has not appeared as a constituent in any analysis made hitherto, we do not look upon that as evidence of its absence, for the reason that this substance was not suspected, and the analysis were generally conducted in a manner to ignore its presence. Besides, all who have analyzed much know that phosphoric acid is a great complicator, and requires special attention and care to appreciate. In small quantities (and all analyses of minerals must be made upon small quantities to give exact results) it may be overlooked, and its presence not even suspected. We feel confident that future research will prove what we have stated to be perfectly true.

Organisms exist, procreate, live, and die, wherever there is heat, air, and moisture. They are in the air, in fresh and salt water, in the arable soil; and their remains constitute the principal mass of immense calcareous formations. It would appear that they are found from the equator to the regions of eternal ice; and according to the observations of the learned Ehrenberg, have been discovered at work in certain localities to the depth of twenty or thirty feet.* If they make a portion of all animated bodies, it follows that this interesting substance is omnipresent, and plays a part in fertilization much more important than has hitherto been attributed to it. An alchemist in Hamburg first discovered phosphorus by evaporating urine and calcining the residuum. Though this was done in 1669, by Brandt, it was not known to the public until many years after, when Gahn and Scheele extracted it from animal matters, and explained their process of obtaining it from the bones of animals, a mode pursued up to the present time. It is a simple substance, of a yellow color, tough, and resembling wax. It may be procured in three states, solid, liquid, and gaseous. At the temperature of freezing water, it is hard, brittle, and even friable. It crystalizes, and its density is about 1.77. Phosphorus, when exposed to the air, is luminous, owing to the fact that it absorbs oxygen and undergoes a slow combustion. Hence its name, from two Greek words, which signify light-producer. When inflamed in the air, or in oxygen gas, it produces white fumes, and when collected free from humidity, is white, pulverulent, and absorbs the humidity of the atmosphere, or deliquesces, and becomes liquid. This combination of phosphorus with oxygen is called phosphoric acid. It inflames easily, and produces obstinate wounds; therefore, it is kept under water, and handled with pinchers. In this condition it may be melted without danger, and is purified by distillation and filtration through buckskin under hot water. Phosphorus combines with oxygen in several proportions; but we shall only dwell upon that which

* See Ehrenberg on Infusoria, and his researches as to the cause of the instability of foundations under the city of Berlin.

contains five atoms of oxygen and one of phosphorus. Phosphoric acid, when perfectly pure, and thrown into water, combines with that liquid with so much rapidity that it produces a noise like that caused by plunging a red-hot iron in water, and the temperature of the liquid is elevated. It is found in Nature, combined with many other substances, forming phosphates: thus we have the phosphates of lime, magnesia, lead, manganese, iron, uranium, &c.

The phosphate of lime is known under the mineralogical term apatite, and is found crystalized in stalactites, granular, fibrous, compact, and friable. It is sometimes colorless, or yellow, blue, violet, and green, transparent, translucid, and opaque. It occurs among crystalized rocks, such as the granite, gneiss, chlorite, and talcose slates; also in the trap and basalts, and is frequently met with in metalliferous deposits connected with copper, lead, &c., in the slates of coal, in chalk, and in the tertiary formations, as well as in the sedimentary and tufaceous deposits forming at the present day.

A fact worthy of note is the connection of fluoric acid with phosphoric in its combinations, and these two substances are not only found associated together in the mineral kingdom, but in vegetable and animal matters. The teeth of animals contain both. We are disposed to believe that fluoric acid is much more common than has been remarked, and, owing to its singular properties, has been doubtless often overlooked. One of the most extensive deposits of the phosphate of lime is found in Estremadura, in Spain, and was visited and examined by Dr. Daubeny and Captain Widdington, with a view to its introduction into England as a fertilizer. That mineral, according to their analysis, contains eighty-one per cent. of phosphate of lime, and is so abundant that it is used as a building material. In the United States, mineral phosphates are found in many localities, particularly in Morris county, New Jersey, and at Crown Point, in the State of New York. The mineral was crushed and sold in our markets as a fertilizer, but, for some cause not known to us, it appears to have gone out of use.

Since writing the above, we have received the following interesting communication from Mr. F. Alger; as it contains a more full account of the native phosphorite of New Jersey and that of New York than we have seen elsewhere, we append it entire.

"I send you a few facts, as requested, in regard to the deposit of mineral phosphate of lime (phosphorite) discovered by Dr. Jackson and myself in Hurdstown, Morris county, New Jersey, in 1850. Crystals of apatite had been found there for several years previous, but the massive mineral had escaped the notice of all who had, up to that time, visited the locality. I purchased the right to explore the minerals with which the phosphorite was associated, viz: magnetic iron, iron and magnetic pyrites, and early in 1851 I made several shipments of it to Messrs. Jevons & Co., of Liverpool, by whom it was sold to various parties for agricultural and manufacturing purposes at prices varying from *twenty* to *thirty-five dollars* per ton in its crude state. Fine, large masses of the substance were placed in the great London exhibition, at its first opening, and attracted much attention, from their *rocky* character, and being unlike any specimen of the mineral before seen. Professors Daubeny, Johnstone, and others became much interested in the discovery, and the latter opened a correspondence with me on the subject, setting forth the advantage which would accrue to British agriculture, if, as a substitute for bone phosphate, guano, or coprolites, it could, at a fair price, be introduced into England. At his suggestion, Dr. Richardson, the celebrated manufacturer of artificial manures at Newcastle, made a successful trial of the mineral, and proposed to negotiate for large importations of it into England for his own use. It was also used in the lead smelting establishments, in the making of cupels in the porcelain works, and in the manufacture of pure phosphorus. For the latter purpose, its purity over bone phosphate highly recommended it, and afforded a most expeditious method of obtaining the beautiful glacial phosphate in the hands of Dr. Jackson, who was also the first chemist who made pure phosphorus from it. In its application to the production of phosphate of soda, for which it has been recommended, I have received no information, though it is probable some of the calico printing and dying establishments, where this article is largely used, may have made a trial of it. Should they, or others, feel desirous of trying it, I shall be glad to supply the mineral in moderate quantity, having yet a supply of it on hand. But I have disposed of my interest in the mine to other parties, who have now ceased to work it. The application of the mineral in the United States has been only to agriculture, and to that by no means extensive, though with the best results. For this purpose it is ground very fine, treated with sulphuric acid to produce super-phosphate, and then mixed with wood ashes and thrown into the compost heap, or otherwise distributed upon the land. In some cases the pulverized mineral has been taken alone and mixed with the compost, but in this way a much longer time must elapse before any beneficial effects can be witnessed. One of our practical agriculturists, who has long supplied milk and meat for the market, said that he had been sending phosphate of lime away from his farm for twenty years, and now he meant to carry some back again. He believed that it would pay, even if applied only to grass lands, as he had no doubt it would find its way into the bones of his animals, and thus prevent the impoverishment of his land. The American chemists who have analyzed and written upon the New Jersey phosphate are Dr. Jackson, Dr. Chilton, Professor Mapes, Dr. Antisell, and Mr. Wells, the editor of the Annals of Scientific Discovery. Dr. Jackson's analysis of a very pure specimen, gave of—

Phosphate of lime	92.405
Chloride of calcium	0.540
Peroxyd of iron	0.040
Oxyd of manganese	0.003
Fluoride of calcium	7.012
By difference	

"Professor Mapes found no fluorine in the specimens he analyzed. He obtained:

Lime	61.50
Phosphoric acid	33.85
Chlorine	3.50
Silica	0.09
Iron peroxyd	0.10
Loss	.96

"The mineral phosphate from Crown Point, New York, has been examined by Mr. Wells. It contained 92.85 per cent. of phosphate of lime, only a trace of fluoric acid, 5.20 oxyd of iron, 0.50 silica, 1.50 water. Later analyses make it much more impure. This has been shipped to England by Professor Emmons, who was the first to make it known under its mineralogical name, Eupyrchroite. It is no longer obtained. The phosphorite from the province of Estremadura, in Spain, where it was at first supposed to exist in large quantity, was analyzed by Professor Daubeny, who was commissioned by the British government to visit the locality, with the view of supplying the English market. He obtained:

Phosphate of lime	81.15
Peroxyd of iron	3.15
Fluoride of calcium	14.00
Silica	1.70
Chlorine of calcium	.31

"The Spanish mineral proved veins in clay slate, and was formerly so abundant as to be used for a building stone. It seems, however, never to have been sent to England. The New Jersey deposit is in hornblende rock, as metamorphic sienite, and when discovered, formed a vein from three to five feet in thickness, running parallel with a vein of magnetic pyrites of about the same dimensions, the two being frequently intermixed.

"F. ALGER."

The coprolites, so extensively sought after, and used as fertilizers, are found in various formations, occurring in limited quantity in the mountain limestone; but the lias, green sand, &c., are the sources whence by far the largest amount is obtained. These nodules, in form and even appearance, indicate their origin. The undigested portions of fishes, scales, bones, and distinct parts of things that once lived, show them to be excrementitious matter, solidified by time and pressure. The coprolites vary considerably in their composition, according to the locality, and partly owing to the variety, some yielding as high as seventy per cent. of phosphate of lime, while others give as low as ten per cent. Some contain, beside phosphate of lime, phosphate of iron, and phosphate of alumine. According to Mr. Nisbit, the analysis of five varieties produced:

Tertiary deposit	19.19 to 22.17
London clay	15.96 to 28.00
Chalk	19.00 to 26.92
Green sand	7.72 to 18.81
Green marl	16.47 to 26.56

Coprolites always contain, beside phosphate of lime and phosphate of magnesia, carbonate of lime, and different substances in varied quantities.

It is needless here to state that the phosphate of lime, or we might say, the phosphoric acid, whether taken from the mineral apatite, or any other mineral phosphate, from coprolites fossilized or recent bones, is the same substance and may be applied with the same advantage.

We have said that phosphoric acid, according to our estimate, is the most valuable substance with which the farmer has to do. Silica, lime, magnesia, and alumine are found in abundant quantities in all parts of the earth; nor does it appear that soda and potash require great solicitude, for the latter, which is the most important of the two, enters into the composition of different mineral substances, all very common, and forming portions of the great mass of the globe. We allude to feldspar and mica, both constituents of granite, and of most of the crystaline rocks. Feldspar contains as high as seventeen per cent., while sometimes mica has not less than twenty per cent. of potash. Of oxygen, hydrogen, and carbon, therefore, it hardly requires that we should feel much anxiety about them. The two former substances combined form water; the latter independent of other supplies, is one of the constituents of carbonic acid, a constant part of the atmosphere. Nor do we think that fertility fails so much owing to the want of nitrogen, for that gas is an ingredient of the atmosphere. Wherever it has been taken, at every height, and from every locality, the air we breathe is composed of oxygen, nitrogen, and carbonic acid, holding 79.00 parts of nitrogen. We shall not enter into the discussion of how nitrogen is assimilated, whether directly or indirectly, whether through ammonia or nitric acid, or other nitrogenized components; suffice it to say, that both ammonia and nitric acid are ever forming in the air and in the soil, and that either of those compounds, the admitted purveyor of nitrogen to plants, is a consequence of the existence and decay of organized matters in the air, or near the surface of the earth. By far the larger part of organized matter is composed of the condensed gases. Even during life these gases are given off and replaced by others. After death, decay speedily ensues, and they return to the great reservoir to be assimilated by other vegetables or animals, and thus continue the circle.

Phosphoric acid, though extensively diffused, and sometimes in large quantities, does not appear to be found in the same profusion as the other substances mentioned. The phosphate of lime is a fixed salt, neither soluble nor volatile, and when removed from the soil must be replaced. This is done in the shape of manures, both organic and inorganic; the main sources of the latter we have alluded to. The amount returned from the barn yard is infinitely less than that carried away in grain, hay, milk, bone, and flesh, even on the most economically regulated farms; and, notwithstanding all our care, there must be a constant decrease of that substance, unless recourse be had to exterior supplies. True, small farms near large cities, may even add more than is taken away, bringing back the refuse of the supplies which are sent to market; but that kind of circulation, from the garden to the market, to the refuse heap, and again to the field, is limited by distance and cost of transportation. Remote lands, from which such supplies are stopped, must in the course of time become impoverished, unless provision be made to replace the continual drain. Exhaustion is but an affair of time; knowing the amount of nutriment in the soil, we may make an approximate calculation, and decide when, under different modes of treatment, it will work sterility. Strong symptoms of a downward tendency in that direction begin to manifest themselves throughout the whole cultivated portion of our country. Indeed, it would be difficult to find, in any part of the civilized world, a more melancholy picture than is presented to the traveler in certain parts of our Union. The exhaustion has not only been caused by continued cropping, and the extraction of phosphoric acid; injudicious culture has had much to do with it, and, perhaps, much the greater part of the fertility has been carried into the streams, thence to rivers, and finally to the ocean. There can be no civilization without population, no population without food, and no food without phosphoric acid. Indeed it might be easily shown, that the march of civilization has followed the direction of supply of that material. There are lands which will not betray the effects of continued cropping, but these are exceptions, and they receive abundant supplies of plant food from some local circumstance. The valley of the Nile is a familiar example; here the annual deposits from the overflow of the river counterbalance the drain. Other lands, composed from the detritus of fossiliferous formations, rich in phosphates, may resist during an indefinite period. The slopes of volcanoes are instances of a different character, where the supplies are restored from ejectments coming from the interior of the earth. The history of the world shows, beyond cavil or doubt, that population cannot endure where the supplies are wanting. Each return of the seasons brings another draft upon the phosphates, and when these fail, civilization takes up another dwelling place. It is not necessary that we should travel far to verify these sad truths. Within the period of a short life, lands were called inexhaustible, which are now worthless; and a great portion of the boundless west is naturally sterile. We are on the eve of a movement from the west back to the east, where a different work is in prospective, that of the regeneration of worn-out land. Perhaps science may be adequate to the task, but the recuperation of a soil will surely be more difficult than cropping it to exhaustion.

If we examine the commercial and agricultural statistics of England for the last fifty years, or even for a much shorter period, we shall be convinced that she never could have attained her present prosperous condition, but from two causes: emigration and the importation of foreign fertilizers. The bones introduced have increased to an enormous extent, during the last few years. "They are principally brought," says Maculloch, "from the Netherlands, Germany, and South America. At the present time, however, they form a part of the export trade of nearly every port in the north of Europe." From a report on agricultural shipping and produce, printed by order of the House of Commons, in 1842, we learn that, out of eleven ports of the northern countries of Europe, bones were exported to a large amount, from the following nine: Hamburg, Rotterdam, Bremen, Lubeck, Kiel, Rostock, Stettin, Elsinore, and Danzic. So far back as the year 1827, two hundred and forty-eight vessels entered the one port of Hull, carrying seventeen thousand seven hundred and eighteen tons of bones, which were derived from Russia, Prussia, Sweden, Norway, Denmark, Hanse Towns, Netherlands, Mechlenburg, Hanover, and Oldenburg. In 1835, the importations into Hull alone, had increased to twenty-five thousand seven hundred tons. The value of bones imported into Scotland in 1841, was seventy-four thousand nine hundred pounds sterling. In 1837, the total value of bones imported into the United Kingdom amounted to two hundred and fifty-four thousand six hundred pounds sterling.* This is independent of the home supply which is estimated at not less than five hundred thousand pounds sterling.

The extensive importations of bones, and the application of the native mineral phosphates, (coprolites, &c.,) together with the introduction of guano, have been the main dependence of agriculture in Great Britain during the last twenty-five years. Science, indeed, has aided in making these supplies more active and efficient, great economy having been secured by improved machinery for crushing bones to fine powder, (for the finer the dust the more immediately active it becomes;) but the dissolution of bones with acid has been of still greater benefit. Farm as you may, upon the majority of soils, without the use of extraneous fertilizers, your crops will certainly diminish, until total impoverishment shall leave no other alternative than starvation or emigration.

Science teaches that the principal fertilizing element of the bone is phosphoric acid, and thus, much is saved in transportation and the economy of application.

Bones vary much in their composition, according to the age or variety of the animal. The amount of mineral matter is less in a young animal than in an old one, and the quantity increases gradually with age. Schreger tells us that the bones of a child contain one half of phosphate in the entire mass of earthy matter, while those of a full-grown person give four fifths, and an aged person not less than seven eighths. The bones of adults contain less water than those of children. When a bone is sufficiently digested in muriatic acid, the mineral part is dissolved, leaving the gelatin, or cartilage, intact, which retains the original form of the bone. Large amounts of gelatin, or glue, are thus made. That portion of the bone dissolved in the acid consists of phosphate of lime and magnesia, fluoride of calcium, and carbonate of lime, with small quantities of salts of potash and soda.

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*Morton's Cyclopædia of Agriculture