petals or stamens of the flowers, and never fail to find phosphates.

In regard to the proportion of phosphoric acid in the crops that we ordinarily cultivate, no plant or part of a plant is so rich in phosphoric acids as the seeds of wheat and rye, where we find in the ash an average of forty-two per cent.; next to those come Indian corn, containing about forty-one per cent. of phosphoric acid in its ash, then barley with thirty-four per cent., oats with twenty-two per cent., potatoes with twenty, the sugar beet with fifteen, turnips thirteen, mangolds and clover eight per cent., and timothy with about seven per cent. But the proportion of phosphoric acid in the ash of these plants possesses less interest for us than the actual quantity of the acid required by an average crop. How much does a fair crop of wheat, barley, or Indian corn carry away from our soils in straw and grain, or a crop of clover or timothy hay, or of potatoes, mangolds, or turnips? And how much is exported from the farm in the crops ordinarily sold? The answer to this last question will tell us how much should be brought back to the farm, in the shape of purchased fodder, or else of purchased manure, to make good the draft upon the soil and to prevent it from losing its fertility.

	Average Bush.	Crop. Wt. lbs.	Pounds of Phosphoric Acid.
Wheat.			
Grain........	25	1,500	12
Straw........	....	2,500	6
Indian Corn.			
Grain.	50	3,000	31
Stover.	....	6,000	20
Potatoes.	150	9,000	20
Turnips........	....	40,000	42
Tops..........	....	75,000	99
Mangolds......	....	40,000	31
Tops about the same as turnips	....	....	
Clover (two cuts).......	....	5,000	25
Timothy.	....	3,000	14

From these figures it would appear that, in any case, whatever we may sell off the farm, the quantity of phosphoric acid removed will be very small in comparison with the stock in the soil, even if we start with only the average proportion of three thousand five hundred pounds per acre, or ten parts in ten thousand. A crop of turnips, which takes up a larger quantity of the acid per acre than any of the other crops mentioned in the above table, would carry off in the roots only forty-two pounds, or about one-ninetieth of the whole quantity; a crop of potatoes, only twenty pounds, one one-hundred-and-seventy-fifth of the whole; a crop of corn about one one-hundred-and-tenth, and a crop of wheat, only one three-hundreth. But in the best systems of farming all these products are not sold; the roots and hay, and in some cases the corn are fed to the stock, and nothing but wheat and other cereal grains, milk, or the products of its manufacture into butter and cheese, and meat, are sold, and in many cases potatoes also. But in all these products there is comparatively little phosphoric acid. With the acre's yield of wheat only twelve pounds of phosphoric acid leave the farm; and with the potatoes only twenty pounds. Sales of corn remove this acid from the farm almost three times as fast as sales of wheat, and one-third faster than the sale of potatoes.

Taking the annual yield of a cow to be two thousand five hundred pounds of milk, if it is all sold, only about six pounds of phosphoric acid would be exported, and this quantity of acid would probably be taken from not less than two acres of land, required for the support of the cow. According to the estimate of Mr. Lawes, for every thousand pounds of live weight of beef animals raised on the farm, fattened and sold, about sixteen pounds only of phosphoric acid will be exported; this quantity, distributed through the whole number of years from the birth of the animal to its sale will amount to a very small draft per annum per acre—certainly not over two pounds. The meaning of all these figures is simply this, that if only wheat, milk, and fattened animals are sold off the farm, and if wheat does not come too often in the rotation, the stock of phosphoric acid in the soil is not drawn upon to an extent greater than from two to three pounds for each acre per year, or less than a hundreth of the average quantity in a good soil. This is slow exhaustion, but, after all, it is sure, and even such careful husbandry as this cannot be practised, if but for half a century, without making a serious inroad on the native stores of plant-food. On how many of our farms, however, is such careful husbandry practised—to say nothing of the reckless waste of manures?

In making these estimates I have assumed that everything that is not sold goes back to the farm again in manure. What quantities of corn and hay are carried from the country to the city—both of them crops that remove large quantities of phosphoric acid, fifteen, twenty-five, or thirty pounds per acre, instead of only two or three as in wheat, milk, and fat animals. In respect to the waste of manures, fortunately, phosphoric acid is not easily lost in this way. It is not volatile, and so it cannot escape into the atmosphere as the ammonia can; but if the manure pile is frequently drenched with water, as is only too often the case, the phosphate may be leached out and carried into the ground under the pile, far beyond the reach of the farmer's spade. In one instance, where an excavation was made under a manure pile from seventy head of cattle, it was found that the earth was coloured blue by phosphate of iron phosphoric acid that had been leached out of the pile, and it was estimated from the analysis of this product, that there were under the manure pile at least 6,000 pounds of phosphoric acid, worth at least five times as much as an equal quantity of phosphoric acid in the field, because soluble in water. The phosphoric acid in the field, especially of a soil that has been long under cultivation, is mostly insoluble; this that was found under the manure pile must have been soluble originally, or it would not have been leached out by the water that soaked throughout the manure.

If there were time for it I might show that lime and potash, ingredients of the food of plants, that are always present in the plant, and in the case of the latter especially, and in quite large and uniform proportions in some parts of the plant, are exported in much smaller quantities than the phosphoric acid, in the plants ordinarily sold. Phosphoric acid appears to be the ingredient of plant food above all others that we have been carrying off from the soils of our farms in the course of the fifty years or more that we have been cultivating them, and it is only within the last few years that we have given any thought to replacing the loss. In England, where soil has been under cultivation for a much longer period, they began to feel the deficiency of phosphates many years ago, and we are now beginning to follow in their track. In Morton's Cyclopædia of Agriculture we are told how the farmers of England began long ago to be discouraged. Their soils had been deteriorating for many years, under somewhat the same wasteful system of cultivation, evidently, that has been so largely followed in this country, especially in the west. A point was reached where, whatever system the farmer followed, his crops were steadily diminishing; in some places the condition of things was so bad that wheat was not included at all in the rotation. It was the introduction of bone manure, just at this point, that saved the agriculture of England, and entirely changed the aspect of affairs.

From the consideration of the relation between phosphate in the soil and the phosphoric acid in the crops that we allow to leave the farm, we pass naturally to the consideration of the important subject of phosphates as manures. I should, however, wear your patience all out, if I should attempt to consider all the forms in which these manures are offered to the farmer. I must therefore confine my attention to the most important one, superphosphate of lime. This superphosphate, about which so much is said now-a-days—what is it? Before I can answer this question satisfactorily, I must digress a little to explain a very interesting property of phosphoric acid, upon which the difference between a superphosphate and an ordinary mineral phosphate, or the phosphate in bones, is based.

In the early part of my lecture I made the statement that there are several phosphates of lime, containing with the same quantity of acid different quantities of the base. Three of these phosphates are very interesting, from an agricultural point of view. Starting with the one which I have already described as the most common, and the only one found in the rocks, and containing for every one hundred and forty-two parts of the acid one hundred and sixty-eight parts of lime, we can prepare from that, by suitable processes, another phosphate containing one-third less lime, or one hundred and twelve parts; and from that another can be obtained containing still another third less lime, or only fifty-six parts. The first phosphate, the starting-point, we may call, as already stated, the tri-calcic phosphate, the substance calcium being one of the constituents of lime. The second we may call di-calcic phosphate, and the third, mono-calcic phosphate. The second compound contains twice as much lime, or twice as much calcium, as the third or last mentioned one, and hence the term di-calcic, and the one first mentioned, contains three times as much lime or calcium as the third, and hence the term tri-calcic phosphate.

In examining the properties of these different phosphates we find a difference that has an important bearing in respect to their usefulness as fertilizers. The tri-calcic phosphate is quite insoluble in water, the mono-calcic phosphate is very soluble, and the di-calcic phosphate stands between the other two as to solubility. This is an important difference, because plant-food in the soil must first be dissolved before it can enter at the roots; and the more soluble a constituent of plant-food is in a fertilizer the more valuable it is, because a larger proportion of it becomes accessible to the plant during the season of growth. No constituent of the soil, or any fertilizer that is ever applied to the soil, is