NESBIT
ON
AGRICULTURAL CHEMISTRY
AND THE
NATURE AND PROPERTIES OF
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NATURE AND PROPERTIES OF PERUVIAN GUANO.

BY

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PREFACE.

THE following Lectures were delivered at various Farmers' Clubs and Agricultural Meetings, during the last few years. Their object was to render more familiar and popular the science of Agricultural Chemistry, and to divest it as much as possible of dry details and technicalities. Having been often requested to publish some of my lectures, I have selected the four following, which I trust will be found to contain in a condensed form the chief principles of Agricultural Chemistry.

The article on Peruvian Guano, first printed in 1851, was very favourably received. I have therefore ventured, after careful revision, again to present it to public notice.

The mode of calculating the value of manures is one which I have for many years adopted, and I trust the ease, accuracy, and simplicity of the plan, will make it of considerable utility to the farmer.

J. C. NESBIT.

Kennington Chemical and Agricultural College,
March 5th, 1856.

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LECTURES

ON

AGRICULTURAL CHEMISTRY.

ON GENERAL AGRICULTURAL CHEMISTRY, AND THE NATURE AND APPLICATION OF MANURES.

In appearing before you for the purpose of offering some remarks on the nature of manures, I do not profess to teach the ordinary routine of practical farming. I aim only at illustrating your practice by observations and instances; and, as I conceive that we are all benefited by having some leading idea to connect together as a whole the scattered facts with which we become acquainted in our ordinary intercourse with things around us, so I think it possible to convey to you this evening that which will place you in a position to combine many of the facts of which you are cognisant, and which will probably induce you to modify your farming operations, in many cases, with considerable advantage. What I shall endeavour to do, then, is to show "of what manure actually consists, its real sources, and how it may most readily be obtained." It is my intention first to take the most general view of which the subject will admit, and then to gradually enter into details and particulars in which you are all interested. If, therefore, for the first few minutes, you appear to be led away a little from the subject, you will afterwards perceive the connection.

Plants, gentlemen, are the main subject of our inquiry this evening. The composition and the habits of a plant must be ascertained before we can know what manures are adapted for it. Now if you examine the structure of ordinary land-plants, you will find that they are provided with roots which are sent down into the soil, and that these roots not merely serve the purpose of retaining the plants in the soil, but are full of minute vessels which have the power of absorbing from the soil materials rendered soluble by water, and of taking them up into the plant and thence into the leaves. The leaves are spread abroad to the air, and when the sap which rises from the roots of the plant finds its way into the leaves, they have the power, during certain seasons, of acting upon this juice, and preparing the materials upon which the plant grows. In other words—for on this point I wish to be very explicit —the roots run down into the soil, and absorb certain materials which exist there; the leaves are sent into the air, and absorb certain materials with which it abounds, and during sunlight or diffused daylight, when there is a certain amount of light and heat in the atmosphere,—that is, in summer or spring weather,—they have the power of uniting these materials and forming the various substances which constitute the fabric of vegetables. Now we thus learn that the roots of land-plants serve other purposes than merely to retain the plants in the soil. The roots of sea-plants, on the contrary, only serve as means of attachment to the rocks. The leaves of sea-plants perform the functions both of the roots and the leaves of land-plants; because, being constantly in contact with the water, they absorb the saline matters from the sea-water, as land-plants absorb the same from the soil by their roots, and they also act on organic elements by means of the light of the sun upon the leaves. The substances which are ordinarily taken up by the roots of plants, and those which are taken in by the leaves, are very different. If you take any vegetable, say wheat, or wheat-straw, or hay, or any other material of that kind, and burn it, you send back into the air the materials which the plant originally derived from the air, and there remain behind, in the form of ash, the materials which the plant by its roots derived from the soil. So that we have a general division of the constituents of any vegetable body into two varieties,—namely, those materials derived from the air, and which may be called atmospheric or organic elements, and those derived from the earth, and which may be called mineral or earthy elements. The terms "mineral" and "organic" may be thus explained: If a plant be burnt, the ashes represent the mineral matter taken from the soil; while the part consumed is the organic matter taken from the air.

It must be apparent to you, from what I have stated, that the whole manuring principle which a plant in its wild state can possibly obtain, must come from the earth and the air. If we look around us, we find that nature is everywhere quite capable of furnishing to wild plants all that they require. Rocks, which do not contain the slightest amount of any material that is obtained from the air, but only mineral matter, after they have been exposed to the air for a while, are found to be covered with vegetables of one kind or another. What is the common action of nature upon a bare rock which is protruded in any way? You first have some lichens (a kind of mushroom) growing over the surface of the rock. These plants have the power, without the aid of anything from the soil except mineral ingredients, of attracting other substances from the air. After generations of these have grown and died, mosses take their place, and grow upon the remains of a kind of mould which has been made by the decay of the lichens. After the moss has grown for some years, you will find different kinds of natural grasses. These are succeeded by others, until at last you have, upon what was originally bare rock, a soil formed naturally, in which trees can and do grow from seeds naturally sown in it. Take, for example, the lavas ejected from Vesuvius, Ætna, and other volcanoes. These lavas, which have been molten and red hot, of course contain no vegetable matter. They have not been long cooled before the wild fig-tree and other plants, sending their rootlets into the interstices, spring up and produce abundance of woody matter, which must evidently have been obtained from the air, as it did not exist in the soil. Take another case, that of a wild waste, such as we find in many parts of Scotland, where pines and other trees have since grown up in a soil which contained at first little or no vegetable matter. These trees have grown for a long period. In the course, perhaps, of thirty or forty years, they are cut down, and hundreds of loads of timber are taken away from every acre on which they were planted ; yet the soil is richer in vegetable matter now than it was before the trees were put there. It is clear, then, that there is something in the air which these plants have the power of obtaining ; and it is this which enables nature to clothe the surface of different rocks with plants of various kinds, so as to present, even when man does not come on the stage at all, a fine scene of foliage wherever moisture and water and other elements of vegetation can be found.

If it be the fact, gentlemen, that plants obtain a great portion of their nutriment from the air, you will see that the consideration of what is obtained from the air and what from the soil is very important indeed to all persons who are engaged in practical farming. Now, if we examine the materials that are driven off by a red heat from any plant whatever, we find them to consist chiefly of four. One is carbon or charcoal. This is a most important element, and is obtained from the air. Whenever charcoal is burnt in an open fire, you have a certain portion of the air called oxygen uniting with the charcoal, and converting it into what is called carbonic acid gas. I would remind you that carbonic acid gas is given out from fermenting vats, and from the burning of all bodies containing charcoal ; and that, speaking generally, whenever any vegetable or animal body is decaying, this gas is evolved and sent into the air. Air contains about two parts of carbonic acid gas in ten thousand. Another of the bodies which plants derive from the air —that is, from the water which comes down from the air—is hydrogen. This is found in all common coal gas. It is also present in water ; nine tons of water containing one ton of this substance. Plants have the power of separating the hydrogen and of retaining it, giving off oxygen into the air. Then we have another body called nitrogen. Nitrogen is the basis of all animal muscle, and is found in large quantities in all the seeds of plants, because they are destined to feed animals, which require its presence to a large extent. It is derived by plants from certain of its combinations contained in the air. Then you have the body called oxygen, which is the vital principle of the atmosphere; which constitutes eight parts out of nine, by weight, of water; and which is abundantly supplied to plants both by water and by the air. I mention these bodies merely that they may be known; I shall not allude too fully to their chemical re-actions, because I wish to keep as free as possible from technical phraseology. Well, now, what is the effect of the leaves of plants upon the air, when they are acted upon by the light of the sun? Plants have the power of deriving carbonic acid from the air by means of their leaves, and of retaining the carbon and sending back the oxygen. They have the power of taking the water in the same way, and when acted upon by the light of the sun, of retaining the hydrogen and sending back the oxygen. They have the power also of acting upon a component of the atmosphere called ammonia, which contains nitrogen, and of retaining the nitrogen and also the hydrogen. This power they exert continually during the full bright light of the sun, and more slowly in the diffused light of day. If any of you wish to try the experiment, get a bottle of soda-water, which contains carbonic acid gas; pour some of it out, then fill the bottle with common water, and invert it in a basin of water; then take a few sprigs of fresh mint, introduce them under the water into the bottle, and expose that to the light of the sun, and you will find a very active operation going on; small globules of gas being given off by the leaves of the mint. Now oxygen is a gas very easily detected, because anything burns in it much easier than in common air, and if you examine the liberated gas, and put into it a bit of paper just red-hot at the end, you will find it blazing in a moment; showing that the carbonic acid gas in the soda-water is decomposed by the leaves of the mint under the action of the sun, the carbon being retained while the oxygen is given off. Another instance of this powerful action under the influence of sunlight is furnished by an experiment tried by a French philosopher. Many of you must be aware that carbonic acid gas, when sent through lime-water, produces a white precipitate. The French philosopher took a long glass tube and inserted in it the branch of a living vine. He closed up one end of the tube, all but a single aperture, through which he sent a current of air mixed with a certain portion of carbonic acid. The other end he also closed, except one tube, which was passed into lime-water. As the carbonic acid would immediately produce a precipitate in lime-water, he could at once tell whether the light of the sun, shining upon the branch in the tube, produced any effect upon the carbonic acid passing through. He first covered the tube to keep out the light, and passed the gas through the tube into lime-water, in which it gave a dense white precipitate. He then removed the jar of lime-water, took the cover off the tube, and let in the light of the sun. He sent a current of gas through the lime-water again, but not the slightest trace was there of carbonic acid: every particle of it had been absorbed and retained by the leaves of the plant for its own use. The leaves had retained the carbon and given out the oxygen. You would hardly suppose that there existed in the air a sufficient quantity of carbonic acid to supply the great wants of vegetation; but if we bear in mind that the atmosphere is forty miles high, that it contains two parts in ten thousand of this gas, and that its weight is fifteen pounds upon every square inch of the surface of the earth, we shall perceive that the quantity is a great many times more than all the carbon that exists in all the vegetation of the earth, and more, probably, than exists in all the known coalfields as well. The fact is, that the quantity of carbon existing in the air would be more than sufficient for a vegetation ten-fold that of the present. In consequence, also, of the continual decay of vegetable and animal matter, and of the whole of the carbon being returned to the air, there never can be any want of carbon for the use of plants.

From the water which falls from the air plants obtain their hydrogen, while they have, at the same time, the power of retaining it, and giving back the oxygen. They have likewise the power of acting upon the ammonia, retaining the nitrogen, together with the hydrogen if they require it. Plants also possess the power of decomposing nitrates, and of retaining the nitrogen. From the soil they likewise obtain the mineral ingredients which they require; for instance, phosphate of lime. We all know that bones contain a large amount of bone-earth, or, as chemists call it, phosphate of lime. Animals feed upon vegetables, and if the vegetables they consume did not contain phosphate of lime, they could not exist. All vegetables, therefore, or those portions of them which are adapted for animal life, contain phosphate of lime; they also contain certain portions of silica or sand in a soluble state, soda and potash, lime and magnesia, common salt, oil of vitrol or sulphuric acid, in the form of sulphate of lime or some other sulphate. These the plants derive from the soil. What, therefore, constitutes manure for the plant is what the plant derives from the soil and the air; that is to say, every substance which is required to make up a plant is adapted for manure. You will see, then, from what I have stated, that the real sources of all manure are the air and the earth. No matter what the manure is, or where it comes from, you can trace it back to these sources—the air on the one hand, and the earth on the other.

Let me here point out to you one or two facts of considerable importance. The first is, that plants in their ordinary natural state, as they are found upon different soils, are adapted to take what they want from the air; yet when you come to work in an artificial manner, which farmers do, this cannot be relied upon. If you were to leave your fields to themselves, you know what would be the result: nature would fill them with plants. But you do not want those plants which nature would put there; you want to grow certain kinds of plants which will yield a profit in the market, but which are not natural or indigenous to the soil, or which would not naturally grow in remunerative quantities; and therefore you will, under these circumstances, have to act somewhat differently from nature, or rather, you will have to assist nature, and make her work for you. One of the great powers which soils possess is that of absorbing from the air certain gaseous materials, the very same substances which plants absorb. Let me for a moment allude to ploughing, or rather to fallowing. What do you do when you fallow the land? Do you not expose the land by repeated turnings to the action of the air? Do you not allow it, if it have any absorbing powers, to absorb what it can from the air? Do you not suffer it to lie in a porous state, and afford it all proper opportunities of acting upon the air? The consequence is, that by fallowing, you cause the porous body, the soil, to act upon the air; and there is absorbed a considerable portion of ammonia, nitric acid, carbonic acid, and other materials essential for the growth of plants. You afterwards take a crop; and is it surprising that you find fallowing beneficial when you have exposed the land for twelve months, without a crop, to the action of the air? You not only secure what the plants can take from the air by their leaves, but have them taking up by their roots from the soil that which the soil has, during twelve months, been taking from the atmosphere. This is the natural system of manuring; and there can be little doubt that, under certain circumstances, it is beneficially practised by the farmer. The process of fallowing is neither more nor less than one of those practical plans by which you place in the soil an additional quantity of the materials which are required for an increased growth of vegetables. It is, in fact, a system of *manuring from the air*.

Now let me here point out, that without draining it is perfectly absurd to think either of fallowing or of ploughing. What is the use of draining? If a soil act by means of porosity upon the air, as I have told you it does, of course when its pores are filled with water no such action can take place. Therefore, it is a *sine qua non* for all farmers, that the soil shall either be naturally sufficiently porous for the water to descend, and the air to enter; or, that it shall be brought into that state artificially—that is, by proper draining. Whatever I may have to say, therefore, with respect to the application of manures in general has no reference whatever to undrained land, but applies to land which is in such a state of porosity that air and water can enter, so as to have their decided, proper action upon the soil.

Allow me to introduce incidentally another point, which I shall dwell upon further when I come to speak of manures. I do not know whether you are aware of the composition of the atmosphere. The atmosphere is a great source of one of the forms of manure. Nitrogen exists in the form of ammonia, as, for example, in ladies' smelling bottles, and as you detect it in your stables; it is also found in the form of nitric acid, as in nitrate of soda. Now, not only do soils absorb ammonia, and also nitric acid, from the air in the manner that I have described, but the air itself, by means of rain, gives every year, to an acre of soil, a quantity of ammonia and nitric acid which would astonish you. It has been proved by some very recent experiments (not yet, I believe, noticed in this country), made by a learned French chemist,* that the rain-water which descends in the neighbourhood of Paris contains a quantity of nitric acid and ammonia which I have estimated to be equal to a dressing of two hundred weight of Peruvian guano per acre. If your land, therefore, is not drained, but is plugged up with water to the surface, the splendid manures which descend in the rain to the extent of which I have spoken will run off on the surface; and, not entering the ground, will not yield more than one-third or one-fourth of their proper manuring value in your crops.

Let me further observe, that there ought to be calcareous matter in all your soils. There is plenty of it in many districts, in the form of chalk, marl, limestone, &c.; and in warm weather there is a process of absorption of ammonia in the air going on naturally in these soils; the ammonia, as it is absorbed, being converted into nitric acid. We are all apt to look upon saltpetre rather as a means of blowing people's heads and bodies asunder than under any other aspect; but we must not forget that it is in fact one of the main articles of the farmer's production. In the wars of our Revolution, in the time of Cromwell and Charles I., all the saltpetre with which the combatants blew one another to pieces was made from the mortar of old walls, the bottoms of old stables, cow-houses, and other places where urine had been deposited; and when we were at war with France, in

* M. Barrall, Compte Rendu, vol. xxxiv. p. 824.

1798, and had cut off its supply of saltpetre from the East Indies, all the saltpetre used by Napoleon was made from similar sources—from the mortar or calcareous matter of old houses, from urine, from animal and vegetable matter collected from various sources, from the bottoms of cow-houses, stables, and other places where urine had penetrated. These, when properly mixed together, produced nitre. The way in which saltpetre heaps were made may be very briefly described. A layer of calcareous matter was put on the ground, being, perhaps, twenty or thirty feet long, twelve feet wide, and a foot deep; on that layer were placed horse manure, straw, animal matter, such as horse-flesh or any similar material, then another layer of calcareous matter, such as marl, and old stable stuff, then a layer of manure, and so on alternately. This heap was kept under cover, so as not to allow too large a quantity of water to fall upon it. It was kept moist by being watered with urine, or urine and water; when urine could not be procured water alone was used. Every three or four months the heap was turned over, being still occasionally watered with urine or water for nine or ten months. After that time it was moistened with water alone; no more urine was added, and no more vegetable or animal matter. In this manner, in fifteen or eighteen months the whole of the nitrogen and ammonia had united with oxygen, and had become converted into nitric acid. This acid, in combination with the calcareous matter, constituted nitrate of lime, nitrate of magnesia, and so on. The heap was then put into a large tank, and well washed with water, which dissolved the nitrates. The liquor pumped away from the residue was boiled with wood-ashes, and this converted it into the nitrate of potash—the substance required. It is not necessary for the farmer to use wood-ashes, because nitrates are all equally valuable to him. Such is the mode by which all the saltpetre was made during our own Revolution, and during the first French Revolution.

I wish now to point out to you, that all soils whatever, containing calcareous matter, which are porous and well-worked, and which have derived vegetable or animal matter from the farm, or from any other source, are, more particularly in warm weather, always acting as nitre-beds: a fact which has not been dwelt upon as much as it ought to have been with reference to the farming of this country. Wherever there is calcareous matter in the soil, wherever the soil is sufficiently porous and duly exposed to the air, there you not only have the material contained in the soil acting, the ammonia oxydising and giving rise to nitric acid, but you have a continual absorption of this material from the air. All artificial nitre-beds give rise to more nitre than the nitrogen in the ammoniacal and other substances put into them ought to occasion; proving that there must be absorption from the air.

This leads me to notice the experiments of the Rev. Mr. Smith, of Lois Weedon, Northamptonshire. That gentleman has been growing wheat upon the same field year after year without the slightest addition of manure; he has, in fact, been carrying out Jethro Tull's plan. Jethro Tull had a notion that by pulverising the soil to a very great extent, he could make it sufficiently fine to pass through the pores of the roots and enter the plants, and that thus he could effectually provide against the want of manure. Now, although he had got hold of a bad theory, his practice was to a great extent sound; as was proved by his producing wheat in this way year after year for a considerable period. His plan, however, went out of use, and has not been followed for many years. Within the last four or five years, the Rev. Mr. Smith, who has a few acres of land which is tolerably stiff, moderately absorbent, and well provided with mineral ingredients, has been trying experiments of a similar nature. Has he succeeded, you will ask, in producing a crop without manure? He has—not without manure in the sense in which I use the word, but without manure in the sense in which you are accustomed to use it. He has not applied cart-loads of dung to his land, but he has made use of methods by which he has been enabled to obtain manure in a form in which you do not generally recognise it; and this is one of the great points I have to bring before you, that you may fully recognise the fact that there are other sources of manure besides cart-loads of dung, straw, or guano. After having well prepared the whole field by thorough digging and forking, Mr. Smith dibbles his wheat in rows of three together, each one foot apart, and with a distance of three feet between every three rows of wheat. When the wheat is up, the one-foot intervals between it are repeatedly dug or turned by a fork about six inches wide, so as not to come nearer the wheat than three inches. Weeds are thus eradicated, and air admitted to the roots. The three-feet intervals are treated throughout the spring and summer as *fallows,* and are thoroughly turned over in every direction, and well exposed to the air. This is done up to the time when the wheat almost meets over the three-feet spaces. When the crop is ripe it is cut; and the three-feet *fallowed* intervals are now dibbled with wheat, while the part which bore the wheat is to be fallow. During the last four or five years, Mr. Smith has taken, on an average, from thirty to forty bushels per acre from his land without any addition of manure in the shape of guano or dung, or any other visible matter. He has, however, been manuring all the time; because, through the constant stirring, there has been a powerful absorption of materials from the air; nitre-beds have been formed, and the result produced is the same that would follow from an absolute dressing of nitrate of soda. In cases where the soil has been light, and where the absorbent power has not existed so powerfully, he has used manure, with, I believe, very fair success. He shows a profit of £4 or £5 an acre on his wheat every year. He every year publishes a fresh statement of what he has been doing, and he says that even at the low price of 40*s.* per quarter, he realises a profit of several pounds per acre. On lighter soils, as I have said, he is obliged to employ visible manures. It is clear that soils must differ in their powers of absorption. The loamy clays, for instance, have a greater power of absorption than lighter soils, and also contain more available mineral matters. With light soils manures are necessary. I have mentioned this case to you, because I want you, gentlemen, to tell your neighbours that manure comes from the air on the one side and the earth on the other, and that a proper working of the land, and a proper exposure of it to the air, will often be as effectual as an actual dressing of visible manure, because the invisible active ingredients of the air are absorbed by the soil to be made use of by the plant.

In the farmer's practice of the rotation of crops, you will find this principle distinctly acknowledged. The rotation, according to the Norfolk system, is turnips, barley, seeds, and wheat. Why is it that this rotation succeeds so well? You would naturally say that, other things being equal, plants with large leaves would draw more from the air than plants with narrow leaves and small foliage. When the turnip is put into the ground it sends out large broad leaves; and when a nice breeze passes over them, and the sun shines upon them, there is a very great absorption of materials from the air, which the turnip eventually puts into the bulb for the purpose of producing turnip-seed. That is the simple purpose of the turnip. "But," the farmer says, "I don't want turnip-seed; I want a little mutton and some barley." If he did not want mutton, he would plough up all the turnips, and put them into the ground to grow his barley. This material, collected in the bulb for the production of seed, is partly consumed by sheep, and the rest is voided by them on the land. The barley is then sown. It has narrow leaves, and it could not absorb more from the air than would produce, perhaps, two or three quarters of barley per acre; but by the use of the turnip previously, which is better than fallowing, because you have a vital agency in addition, a large amount of nutriment is placed in the ground, which the barley lays hold of, and there is a great increase of crop in consequence. After barley, as preparatory to wheat, you take a plant with large foliage, red clover, or some other clover, which is mixed with grass-seed. Now what does the clover do? Every little leaflet which it shoots up into the air sends a rootlet downwards; so that in proportion to the upward growth of the clover is the downward growth of the root, and when you have taken the clover away you retain in the shape of roots several tons per acre of valuable vegetable matter, which, by its slow decomposition, affords nutriment for the narrow-leafed wheat. So that by employing, in the first instance, turnips for the barley, and clover for the wheat, you accumulate in the soil a large quantity of material absorbed from the air, for the benefit of the after-crops. This may be clearly seen if you consider the difference between cutting clover and feeding it off. It is generally believed that a man who feeds his clover off, with a little oilcake, etc., will get a better crop than one who takes the hay. I know I am here treading on tender ground, but, at the risk of being accused of heresy, I will aver, that the man who spends his money on oilcake, feeding it off upon clover, is committing an error, unless he can realise benefit in the shape of mutton. If you cut clover at midsummer, and let it grow again, and then take another cutting in the autumn, you will afterwards obtain a far better crop of wheat than you would secure by feeding with oilcake, unless you chose to go to an enormous expense. Every leaflet upwards has a rootlet downwards, and if the leaflet be taken off, the rootlet will not grow; so that if the sheep be fed upon the surface, the under production is diminished. In exact proportion to the increase of the upper is the increase of the lower; and if you are always feeding off the former with sheep, you will have but few roots below, and the small amount of nutriment you give in the shape of oilcake will produce little or no effect. A friend of mine tried this in Northamptonshire. He had a field of clover, which he divided into two parts. The whole was cut at midsummer, half was left to grow again, and the other fed off. In October, he staked out two pieces as regularly as possible, and had all the roots dug up, and carefully cleaned and weighed. The result was, that where the clover had been cut once and eaten once, there were twenty-five hundred weight of roots per acre, and where it had been cut twice, there were seventy-five hundred weight per acre; being a difference of two tons of roots per acre. Who will say, then, that two tons of vegetable matter, containing so much nitrogen as these roots do, were not an exceedingly good dressing? Of course, the result in the wheat crops was perceptible at once; and you may depend upon it, that, with one exception, namely, where soils are so light that the mechanical treading of the feet of sheep is a matter of prime necessity, you will always get a better crop of wheat after two cuts of clover than by feeding off.

There is one point which I must mention with respect to turnips; because, in order to get a clear notion of manuring, you must attend to many minutiæ. Some farmers have a notion—I have found it general—that sheep and other animals have the power of imparting something to vegetable food, so as to convert it into manure. This is a great mistake. Whether the vegetable food passes through the body of the animal, or goes at once into the soil, if you can ensure a regular decomposition, the effect will be the same. Take the case of a crop of turnips. Suppose you have two pieces of land, each producing twenty tons per acre, and in the one instance you chop up the turnips and spread them on the land, and in the other feed off with sheep and then plough the whole and sow it with barley. I maintain that you would have a much larger crop of barley where you did not feed the sheep than where you did; that where the turnips were, by themselves, cut up and ploughed into the land, you would have much more nutriment adapted for the succeeding plant than where you fed the sheep upon it; because, while you feed the sheep, it wants something to supply the natural waste of the body, and to increase its bulk, and, after these are supplied by the turnips, the sheep leave on the soil a smaller quantity of vegetable matter to serve as manure than was contained in that upon which they originally fed. Whence can a sheep derive manure except from its food? It has no power of deriving it from any other source, because the animal is only a consumer—it does not impart anything. Therefore, feeding is only a waste, unless you realise a benefit in regard to your stock, which I am happy to find you are all doing. I have known the time when turnips were so abundant that there was not stock enough to feed them off; and when they were ploughed into the land, it produced better crops of barley in consequence. I applied to a number of my friends to try some experiments of this kind, and I have one or two letters here respecting the results, which, with your permission, I will read to you.

"Old Broad Street, August 10, 1849.

"In reply to your letter, I am instructed to say that the members of the Farmers' Moon Club, in the neighbourhood of Rochester, Kent, unanimously agree, that vegetable manures are peculiarly fructifying, and that, taking the case of a fallow or other field, being all previously of the some tilth, and sown with rape for feeding, and divided into three divisions, one of which shall be fed off with sheep without any extra food to the rape, the second division ploughed in, and the third division fed off with oilcake or corn; that the worst corn succeeding the rape, will be on the first division, the next best on the second, and the best on the third. Thus all speak in favour of green crop for manure.

"JOHN OAKLEY.

"J. C. Nesbit, Esq."

"Naseby, May 15, 1849.

"I regret I was not at home to answer your inquiry sooner, having been in Yorkshire the last fortnight; however, I hasten to send you the required information. In the spring of 1846 I had more turnips than my stock could consume; I thought that it was reasonable that, if the crop was broken to pieces and ploughed in, the grain crop that followed would derive as much benefit as if eaten by sheep. I therefore did so with one acre, in the first week in February, and with another upon the fourth week in March. Part of the rest of the field was eaten on the land, and part being newly ploughed-up land, the whole crop was drawn off. On the land where the turnips (white rounds) were broken and ploughed in on the last week in February, the produce was eighty-four bushels per acre of Hopetoun oats. Where the turnips were broken and ploughed in on the fourth week in March, the produce was seventy-four and a half bushels per acre. Where eaten on the land by sheep, seventy and a quarter bushels per acre; and on the newly ploughed-up land, the whole of the crop drawn off, forty-one bushels of wheat.

"PETER LOVE.

"J. C. Nesbit."

"Assington Moors, June 15, 1849.

"I have just seen Mr. Underwood, who was a neighbour of mine eighteen years ago, but is removed to a distance. He says he has practised ploughing in a few acres of turnips almost every year for upwards of twenty years, and considers three sacks of barley per acre quite within bounds, as the increase from ploughing in over feeding off. The clover is much better; but he has not observed the wheat sufficiently to say what the difference is. He estimates an average acre of white turnips to be worth thirty shillings more to chop and plough in, any time before they begin to run to seed (say February out), than to feed off. I inspected a field of wheat this week, belonging to John Gurdon, Esq., which was white turnips three years back; a part was ploughed in, and the rest fed off with sheep, half a pound of oilcake per day being given to each of them. The wheat, where the turnips were ploughed in, is decidedly better than the rest—I think three bushels per acre. Mr. Hudson, the steward, told me the barley was quite a foot higher than the rest of the field, and three sacks, if not more, per acre better. The clover was all fed off, and no notice taken; nor would anything more been thought about it, had not the wheat looked so much better than the rest all the spring. The turnips were about three quarters of a plant, but regular; the sheep went down with the epidemic, and were sold, leaving about two acres of turnips to feed; and rather than purchase any more stock they were ploughed in. As I told you at the club, I am generally a buyer of turnips; but the obstinacy of my neighbour, Mr. Underwood, who refused to take twenty shillings per acre for his, to feed off (for the sake of convenience to me) when almost everybody else was giving theirs away, attracted my attention to the after crop; and I can, in two instances, confirm his statements. Notwithstanding, if one and a half hundred weight of Swedes (I think a ton of Swede turnips will make fourteen pounds of mutton, from experiments I have tried), or two hundred weight of white turnips—will make one pound of mutton, and we can grow twenty-one tons of the former, and twenty-six or twenty-eight of the latter, it must be more profitable to feed at fivepence per pound for the mutton, than to plough in to gain thirty shillings or forty shillings per acre in the corn crop. I have been unwell, and could not see the parties, or I should have answered your note before.

"THOS. HAWKINS.

"Mr. J. C. Nesbit."

There is one part of the first letter in which I do not quite concur. It is the decided opinion of the farmers, in most districts where the experiment has been properly tried, that turnips or rape must be far better for the next crop when ploughed into the land than when fed off with sheep, even with the addition of oilcake.

This brings us at once to green crops. Supposing you had a farm of a thousand or more acres, and could not stock it at once, one of the best means of increasing the fertility of the land would be to grow rape, or some similar crop, and plough it in, because rape derives from the atmosphere a very large amount of the volatile materials contained in it, and thus for the next crop you would have in the land an abundant supply of manure. It is thus that wheat is grown in some parts of America. It is the plan of the growers there to sow clover and plough it in; then comes a wheat crop; and after the wheat they fallow for a year, to clear from weeds, and then put in clover again. They take wheat in this way every three years, and follow no other mode. They use clover simply for the purpose of obtaining nutriment from the air.

We now come to the preparation of farm-yard manure. This is generally formed of all the vegetable matters lying about the farm, together with the dung deposited by stock. Now, whether vegetable matter be disintegrated by spontaneous decomposition, or by passing through animals, the result is the same. If I pass a certain quantity of food through the body of an animal, which is continually absorbing air into its system, that air is constantly acting upon the food, and consuming some of it, so that what the animal gives out afterwards is of less value than what it received. If a quantity of straw be trodden down by animals, and thus rotted away, there ensues the same action that proceeds inside the animal,—that is, the air acts upon the straw, burning a portion of it, and giving out into the air carbonic acid, ammonia, and water, from the decomposition of the vegetable matter; so that whether you pass the food through the body of the animal, or decompose it in the open air, the ultimate result is the same. There is always something passing into the air for the general supply of nature's fields; the rest remains in the shape of manure. That which passes through the animal is richer than the ordinary farm-yard dung, because of the greater richness of the food it has consumed. If you feed an animal on straw alone, its excrements will be no richer, as regards manure, than straw decomposed in the open air; but when you feed upon seed, which contains four or five times more nitrogen—a substance capable of producing ammonia—than straw, and which also contains far more phosphates, the excrements are more valuable than decomposed straw. In no other sense are the results different. If you took a quantity of wheat or linseed, and allowed it to rot, instead of feeding animals with it, the residue would be as valuable as the dung expelled from the animal. Therefore, while you use valuable food, because you gain by the conversion of it into beef or mutton, that which is excreted or given out is only valuable because you use a valuable material to produce it. Manure from animal matter resembles manure from vegetable matter. We are, in fact, like so many steam-engines; we are obliged to have our air and our fuel or food to maintain our operations; and that which is unconsumed is cast out, like so many ashes in our grates. Many animals live upon vegetables, and carnivorous animals live upon animals that live upon vegetables; so that whatever animal manure you use is really derived from the vegetable kingdom.

In the case of farm-yard dung, you simply return for the production of new vegetables what formed part of the old. You only replace on the land what you have taken from it. According to the circumstances in which you happen to be placed, you make, in various ways, farm-yard dung out of vegetable matter. Some persons put a quantity of straw in a yard, turn in a number of cattle, and there supply them with food. The cattle tread the straw about, and after it has become a little decomposed it is called farm-yard dung. Others, again, feed their cattle, in boxes, with oilcake, and hence we have another variety of dung. But, whatever the process may be, you will find that the dung is neither more nor less than materials which once grew on the land; materials which, having once had vegetable life, are put on the ground again to sustain that life. It is a simple, but most important fact, that what once formed part of a vegetable can become part of a vegetable again.

In the management of farm-yard dung there are a few things worth noticing. Some of the constituents of farm-yard dung are volatile, and go into the air; others are soluble in water, passing away if there is too much water; while the most worthless are the least volatile and the most insoluble. Ammonia, one of the most valuable constituents of all manures, is that which is the most volatile, and if you allow too great heat in the decomposition of vegetable manures, the ammonia, as it is produced, is driven off into the air. Again, if—as is the case, I am afraid, rather too much even in this part of the country—you allow all the water that falls to go upon your manure, even that which comes from buildings and out-houses, you wash away all the soluble materials; and dung that has parted with these volatile and soluble materials is like so much green thatch—it is not more valuable, and produces no better results. If you want to buy pure ammonia in the commercial market, you must pay at the rate of sixty pounds a ton for it, in any manure in which it is to be found; and if you want to buy phosphates and other materials of that kind, you must pay a very high price for them. You should, therefore, be very careful to prevent waste. One of the best methods of preventing the waste of ammonia, where you cannot put dung on the land at once, is to make compost heaps of it—in fact, nitre-beds. I have seen to-day, while riding out near Driffield, a quantity of dung without the slightest covering upon it; a large proportion of it having been exposed to rains, which must have washed away the ammonia, the nitre, and everything else in it that was useful. I asked the man why he did not lay it up, and put a layer of ditch-stuff upon it. He said, "Perhaps it would have been better, Sir." This, however, had not been done. If the farmer had made a layer of road-stuff, of which there are hundreds of loads within a few yards of the field—then put one of dung, then more road-stuff or soil, and so on, covering the whole with the earthy matter—he would have had a complete nitre-bed; he would have had the whole of the earthy matter impregnated with the gases given off by decomposition; and he would thus have secured a much more valuable manure than the washed dung which he is now putting on his land. This nitrification can be always carried on by you, gentlemen. There are times when you cannot put dung upon the land; and what are you to do then? The best thing is to use some calcareous matter—marl or something of that kind, and to lay the dung up in such a form as to be easily mixed with it; turning the mass over once every two months. The earthy matter will prevent its being too light, and also prevent too great decomposition. The grand point is to guard against decomposition going too far: you should take care to let it proceed slowly and regularly.

There are many who like well-rotted spit-dung. Were I going to buy this at so much per ton, I should probably seek that which had been rotted for some time; but if I made my own, I should proceed very differently. A hundred tons of new dung are certainly more valuable than a hundred tons of the same dung rotted down to fifty tons; but, on the other hand, a ton of the fifty may be worth more than a ton of the hundred, and therefore, though I might be inclined, when buying dung, to prefer that which is well rotted, it does not follow that I should rot it down myself. In the case, therefore, of lands not over light, which would not be injured by long straw being put on them, fresh dung is the most serviceable; a hundred tons of fresh dung would do more good upon such land than a hundred tons of the same kind of dung wasted down by decomposition to seventy, sixty, or fifty tons. I cannot too much impress upon you the necessity of preventing too great decomposition from taking place; unless you put something to absorb the gases given out, so as to form a species of nitre-beds.

Farm-yard dung, as I told you before, essentially varies in value according to the substances from which it is made. If you practise box-feeding—if you feed your bullocks in boxes, you should follow Mr. Warne's plan. If you feed with linseed, and other strong food, the manure ought not to be exposed to the wet, but should be stacked up—I was going to say, as you would stack up barley—or mixed with soil as before described. Some covering should always be over it; and if that were done in the way I have mentioned, calcareous matter being mixed with the manure, you could make manure which would act, proportionately, quite as strongly upon your land as any nitrate of soda which you could use.

There now arises a question as to the general application of farm-yard dung to different crops. I had better, in speaking of that, just mention that in all lands there ought to be a certain amount of lime. Though you are living upon the Wolds, which is quite a chalk district, I must tell you I have known very good results arising from putting chalk upon chalk. In Hampshire, and in various counties where the Downs have been exposed for years and years, I have taken some of the soil within a few inches of the surface, and tested it for chalk, and have scarcely found a trace; and having recommended gentlemen there to lime or chalk these Downs, whichever might be the best and cheapest, my recommendation was followed, and in the result was productive of an increase of verdure. It does not follow, that on the very surface of a chalk or limestone soil, you should have chalk or limestone. There is a tendency in chalk and limestone to go downwards. If, a few years after a field has been limed, you dig it, you will probably find a layer of the lime some inches below the surface. In some of the hop-fields in Kent, where the hops grow upon limestone rock, I have taken the surface of the soil, and have not found one part in a thousand of carbonate of lime. I therefore recommend chalk or lime upon soils known to be formed of limestone itself; because of the general tendency of calcareous matter to be washed downwards.

Let me say one word with respect to the application of farm-yard dung in general, before I speak of the so-called artificial manures. How should it be applied? Some apply it to wheat, some to grasses—some to one crop, some to another. There has been a great dispute in the south as to whether farm-yard dung should be applied for wheat directly in the autumn or whether it should be applied upon the grasses. Many advocate the putting of it on the clover at midsummer; and in almost all cases where it has been so tried it has produced a good effect. I carry that plan a little further, and, instead of applying farm-yard dung for wheat, in ordinary cases, when the wheat is about to be sown, or on the clovers at midsummer, I apply it in the autumn or spring before, upon the clover. The result of pursuing that course is this: You give the clovers a thoroughly good dressing, so as to enable them to grow with much greater rapidity, and to much greater volume; you also have a far greater amount of roots produced in the soil; and the wheat derives a greater benefit from those roots, in the shape of manure, than if you applied the manure at midsummer, or when you plough up the ley in the autumn. Wherever this plan has been tried—and it has been tried in many places—it has been found efficacious. Experiments have been made, distinctly showing that it is better to apply farm-yard dung to green than to corn crops.

With respect to artificial manure, so called—there cannot strictly be any such, because, wherever manure exists, we can trace it all back to natural sources. Bones are known as very efficacious sources of manure, particularly in this district. What are bones? You get them from animals; animals live upon plants, and all the constituents of plants come from the earth or the air. Then you have guano. Whence does guano come? It is the deposit of sea-fowl; these sea-fowl feed upon fish; the fish feed upon vegetables in the ocean; the vegetables in the ocean, under the light of the sun, feed upon minerals and other matters existing in the ocean; so that even Peruvian guano comes from vegetables. I have here a sample of dried flesh from Buenos Ayres. How is that produced? It comes from bullocks, of which many thousands are killed for the sake of their hides, which are sent to England. Thirty or forty thousand hides of these wild cattle are imported every year. These animals graze upon the prairies and the pampas of South America, and they get their flesh from the vegetables on which they feed. The question arises, which is the most valuable of these various manures? If you examine all those which are found practically to be productive of the greatest benefit, you will find that those which contain the largest proportion of nitrogen or ammonia, and the largest proportion of phosphate of lime, are those which prove of the greatest advantage to the farmer. Theoretically, we should say that a manure was perfect if it contained every constituent that is found in a plant. That would be, theoretically, a perfect manure, if you intended to grow plants upon a soil which contained nothing. But, then, if the soil contain certain ingredients; if it have a certain amount of soluble silica, potash, soda, and other materials of that kind, which most of the soils of this country have, in that case whatever the soil happens to be most deficient in will of course be found most beneficial; and it has been proved by experiment, not only here, but in France, in America, and in many other parts of the world, that those bodies which contain nitrogen, and those which contain phosphate of lime, are the most valuable for manure. Now, you know that, do what you may, save your manure as you will, there is a constant loss upon the farm; that, though you may, by proper working of the soil, get a very considerable amount absorbed from the air, yet there is always a loss—that there are few instances in which sufficient manure can be obtained by ordinary farming, and without importation from other sources of supply. I assert, generally, that unless you import phosphates and nitrogen, your farms cannot be much benefited by manure. Potash and soda have been used in large quantities, but without any general, or long-continued, distinct effect, except so far as salt is concerned, of which I shall speak hereafter. We have had silicates of soda, and a great variety of other materials, much spoken of; but only those which I have mentioned seem to have been generally productive of good effects.

Well, now, in treating of manuring we must take the separate crops, beginning with the turnips, and see what are the best manures for them. I think that, so far as experience has tested the matter, bones have been found in this part of the country, and in almost every other, to be one of the best manures for turnips; but, then, you have had to put on a large quantity of bones per acre, and after you have taken your turnip crops you have found a great deal of bone left which has evidently exerted no action at all. It was the celebrated Liebig who suggested that if the bones were made more soluble their action would be quicker, and the expense to the farmer less. He suggested that they should be made soluble by a process well known to chemists. Bones can be dissolved in a variety of ways. A method which has been known for fifty or sixty years—namely, by the use of sulphuric acid—was the one recommended by Liebig. He proposed that sulphuric acid should be applied to bones, so as to dissolve a portion of the lime, and set the phosphoric acid free. This has been generally done, and I believe no suggestion in chemical science has been productive of such immense advantages to agriculture as this simple one of Liebig; because, instead of throwing a quantity of bones upon the land, which apparently are very good for the landlord—I say apparently, because he sees the bones there—you now put in just as much as the crop requires, and not a farthing's worth more. It ill accords with my notion of what farming in the present day ought to be, that a man should put a sufficient quantity of manure upon his land to last for nine or ten years, losing the interest of his money for the whole of that time. As well might he put £10,000 into a bank, and keep it there for ten years, simply because he might want to spend a thousand a-year, thereby losing some hundreds a-year of interest during the period. The introduction of artificial manure has inaugurated a new era in the art of farming. Most cotton manufacturers, we know, turn over their money every two or three weeks, and are exceedingly careful not to lay out a penny on which they cannot realise a profit; and I would impress upon you, that if you proceed on the old system, when you have the means of determining exactly how much manure you require, you are only wasting your capital and losing your interest. You can grow any crops you like by attending to this matter. Is it not foolish to administer at once to the soil as much as would suffice for three, or four, or five crops, when the land is subject to all the vicissitudes of rainy seasons, when almost everything soluble must be washed out of it? Instead of a quarter or a quarter and a half of bones being necessary, as formerly, a few bushels, acted on by a third of their weight of acid, and rendered soluble, will produce not only an equal but a better crop, and some effect may even be seen in subsequent years.

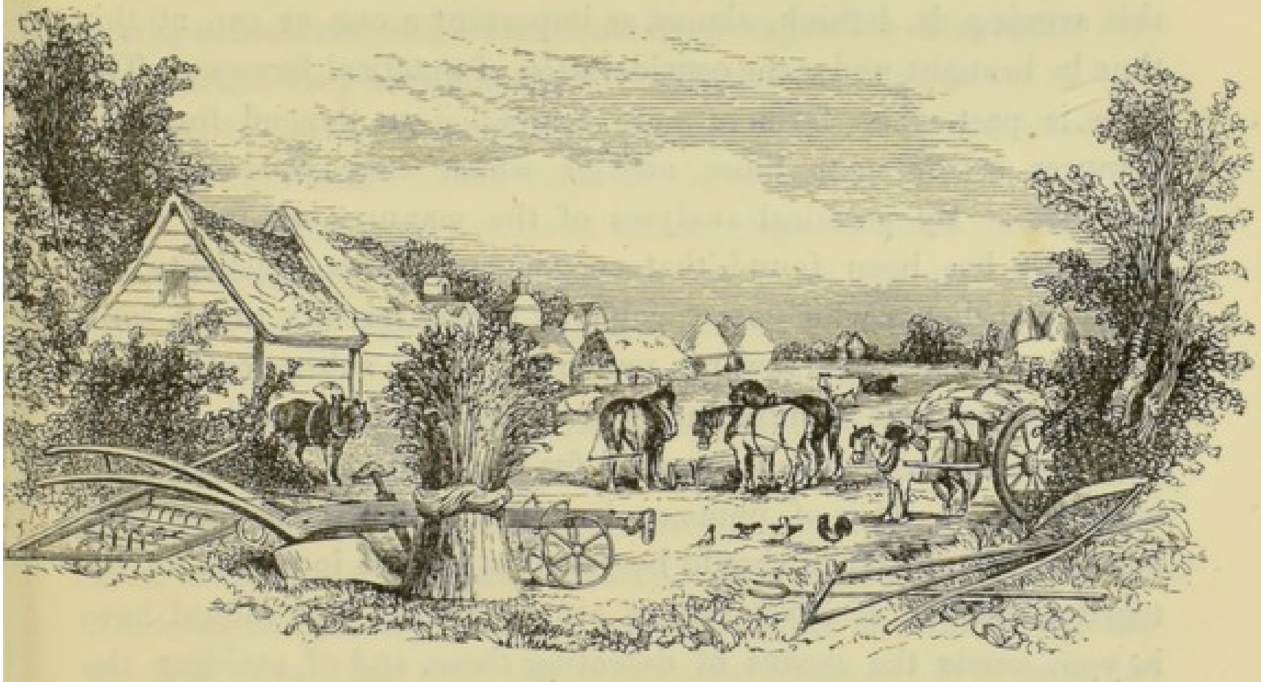
Artificial manures are valuable in another point of view. You are not always obliged to feed your turnips off upon the land, but you may want them, in some instances, at home. If, in consequence of this, your barley does not, in the spring, look as satisfactory as it ought, you can now improve it, whereas before you were obliged to leave it to its fate. A little guano or nitrate of soda and salt—about three quarters of a hundred weight of either guano or nitrate of soda, and four hundred weight of common salt —for either wheat or barley looking badly in the spring, will produce an immediate effect. You will find, particularly in hilly districts, that a great breadth of land not hitherto cultivated for turnips, or cultivated with difficulty, in consequence of the immense expense of carrying farm-yard dung, can be brought by these artificial manures into a high state of fertility; and I need not tell you, that if you get twenty tons of turnips per acre, your cultivation for the next four years will be pretty well established. In Wiltshire and other places in the south, the introduction of these portable manures has been the actual salvation of the country. In that district farmers with whom I am well acquainted have been paying high rents for low-lying lands—smaller rents, it is true, for the high lands, but between the two the rental has been considerable. The hills there are rather more abrupt than the ordinary run of hills in this neighbourhood, and it was found exceedingly difficult, indeed almost impossible, to cultivate them ; but since the introduction of portable manures, by the application of guano, superphosphate, or manures of the same kind, to the hill land, agriculturists have been enabled to obtain a great quantity of turnips, with which they have fed an increased stock of sheep. I have not heard any grumbling from them for the last three or four years ; they have been doing well by their stock ; and if you, gentlemen, can grow more food, and keep a larger number of stock—if you can manage to keep an increased quantity of sheep, and sell them at good prices, and also dispose of your wool at 17*d*. or 18*d*. per pound, I think the cry we have had about the fall of British agriculture will prove to have been perfectly unfounded.

I have, I believe, given you a pretty clear notion of what are the best manures for these crops. I may say, generally, that for wheat those manures are the best which contain ammonia or nitrogen, with a certain amount of phosphates. They must be applied carefully, because there is a liability to throw down the wheat; and, in order to prevent that, I must recommend you to use salt. Salt is not a thing which shows itself conspicuously in the production of great luxuriance, but rather in giving strength to the stem of the wheat. In Lincolnshire you will rarely find the wheat falling on the salt marshes. Two hundred weight of guano and four hundred weight of salt is a good dressing for an acre of wheat. With respect to grass land, according to the experiments of Professor Kuhlmann, the amount of grass produced on any given acre is in direct proportion to the amount of ammonia or nitrogen used. In reference to grass and clover, you have not much cause to fear excessive luxuriance. The more you apply of those manures which contain nitrogen, the greater will be the production of vegetation. Professor Kuhlmann applied gas-water, nitrate of soda, ammonia, dissolved bones, and a great many other things, to grass land; and he found, as the result of his experiments, having ascertained previously by analysis the amount of nitrogen in these materials, that the increase of the crop was precisely in proportion to the amount of nitrogen in the manure. He tried the experiment for two or three years. He took not only the first crop, but the second; he cut them, and found an increase, relatively, in the second as in the first. Having had experiments tried on the Downs in Dorsetshire, with ammoniacal manures, I have myself found the production of grass largely increased thereby. I mention these things, because you will have to turn your attention a little more to science than you have done, so as to ascertain the nature of the manures which you are using.

Now let me say a word, in conclusion, with respect to the adulteration of manures. Good guano ought to contain sixteen or seventeen per cent. of ammonia, and from twenty-five to thirty per cent. of phosphate of lime: I am speaking of Peruvian guano. There are many other guanos brought into this country, and I will just tell you what they are selling at. Guanos, of which I have had hundreds under analysis, have been selling in the market at

£8 and £9 per ton; but to you they are not worth a third of that amount. I wish to warn you, that if you procure guano from any but the best sources, it is a thousand to one but you are cheated, as many persons, I fear, have learnt to their cost. It is far better, I should observe, for you to give your orders for manure before than after Christmas, because after Christmas there is nearly always more uncertainty about it. The ships may not come in; and if the importers know what demand is likely to be made, they will be the better able to meet it.

Adulterations of guano are carried on to an extraordinary extent. The other day I happened to be in Newcastle, and I can assure you that there is a regular establishment there for the purpose of sending into this neighbourhood, and into Hull, Stockton, and other places, systematically adulterated articles to the extent of thousands of tons. They are sent off quietly, to prevent the trickery from becoming known, and are of course flavoured with a little genuine guano. The adulterated article is bought up by those farmers who like to purchase a little under market price, and who are, in consequence, shamefully cheated. Every farmer, in fact, who tries to buy cheap manure, is sure to be deceived; because, if he will have it cheap, people will be found to make it at his price, and he will have to pay the cost of mixing, and probably fifty per cent. besides. If manures are worth using at all, they are worth a proper price. Manures of the lowest price are the least valuable to the farmer. If he could obtain a manure intrinsically worth £50 a ton, it would be proportionately more valuable to him than Peruvian guano, because of the saving of carriage, and other facilities arising from its small bulk. You cannot, therefore, be too careful in purchasing these artificial manures. I am, myself, extensively engaged at the College in the analysis of manures, and shall be very happy to render to the farmer any assistance that may be required, in certifying him as to the quality of any particular manure. Let me advise you, when purchasing the article, to deal with none but men of established character and integrity. Do not try to buy everything cheap, for it is certain that you will be cheated if you do. The quantity of adulterated guano annually made up cannot, I think, be less than twenty or thirty thousand tons, and I estimate the lowest amount of which the farmer will thus be defrauded at £100,000 per annum. The adulteration of artificial manures is, however, of sufficient importance to form the subject-matter of another lecture.



THE ADULTERATION OF ARTIFICIAL MANURES, AND THE BEST PRACTICAL MEANS OF DETECTION.

THE subject which I have the honour of introducing to your notice this evening, is, I think, almost as important a one as can at this time be brought under the consideration of practical farmers. The time is past when farmers were compelled to depend for their manures solely upon those articles which they produce upon the farm. By practical analyses of the manures used in cultivation, it has been found that certain substances constitute the chief ingredients which are capable of giving fertility to the soil; and, as you are well aware, numerous other substances, either obtained from our manufacturers or brought from abroad, such as nitrate of soda and guano, are used for the purposes of agricultural improvement. It is of immense importance that the articles thus brought to your farms should be received by you in a state of integrity, and that if adulterations are carried on, you should have in your hands the means of detecting them, and of avoiding the loss which you might otherwise sustain.

I shall endeavour, gentlemen, in this lecture, to show you of what good manures consist—what are their principal constituents, and afterwards to give you the whole history of the adulteration of manures, showing you how and where it is practised. I do not mention the names of parties,—it would not be prudent to do so; but I shall give you such evidence as to the extent of adulteration as will, I hope, lead every farmer to be very cautious in what quarters he buys manures.

Now let us examine, in the first place, in what the value of manure consists. It is quite evident that if manures be useful in eliminating and bringing forth the elements of the crop, and tend to produce luxuriance, the cause is not to be found in every ingredient alike, but in some one or two of the constituents. You are well aware that the old staple manure was farm-yard dung. Farm-yard dung is the result of the decomposition of vegetable matter, of materials originally derived from the soil and the air; the vegetables deriving one portion of their nutriment from the soil and another from the air, the two combining by the action of solar light. When these vegetable substances are put on the land, whether they are eaten off by sheep and bullocks, or ploughed in, you get certain elements in the land which serve the purpose of manuring; in other words, substances which once sustained vegetable life, again sustain it when they have undergone sufficient decomposition.

This being the case, we must inquire which of the constituents found in these manures and crops are the most valuable. I need not tell you that the money value of a thing depends much on the difficulty of obtaining it. If diamonds were found scattered about the road, their value would be no greater than that of flint or granite; it is the difficulty of obtaining them which so enormously enhances their price. Now you have in farm-yard dung, first, a large amount of water. The common dung which is put on the farm, and which is so highly prized by the farmer, contains seventy, eighty, and, in some cases, even ninety per cent. of water. It is evident that, as the air of heaven continually furnishes us with a large amount of water in the form of rain and dew, this constituent ought not to be regarded as very valuable in manure. It is, in fact, just the contrary. The wetter the manure, the worse it is. To go a little further: what is the least valuable ingredient after water? Here we come to carbonaceous or mere woody matters. These are absolutely required when you are farming on a large scale; and in putting on twenty or thirty loads of dung per acre, you apply a sufficiently large amount of carbonaceous substances to be of great value in the field. In so doing you act quite correctly; but when you put three hundred weight of guano against fifteen or twenty loads of farm-yard dung, the equal effect of the guano must be owing to something more than the mere carbonaceous materials. It is not these alone which do you service; for the proportion contained in guano is very small. One ton of guano contains only eight or nine hundred weight of carbonaceous matter, which cannot be the great staple of manures; and, although it may be useful to put this on the land, either by ploughing it in or by applying it in the shape of straw, yet I cannot set any great value on this alone—it is equivalent to so much saw-dust; and the putting of a large quantity of decomposed sawdust on the land would produce equal effects. When I speak of the application of carbonaceous matters, I do not refer to charred materials; because in that case a change has taken place, and the matter has acquired other properties. To mere woody organic matter, then, I say, we cannot properly attach any considerable value. Again, common salt is found in farm-yard dung. We may, perhaps, find one per cent. of that ingredient; but this proportion is too small to be highly prized. I might go on to allude to various other ingredients; but if I did so, it would all resolve itself into this—that the nitrogen, and the phosphate of lime or bone earth, constitute the elements of chief value in artificial manures.

Now in farm-yard dung, so far as I am able to judge—and my opinion has been corroborated by that of many others—there is seldom one per cent. of ammonia, though in the case of the dung of animals which have been highly fed, you may get a little more; and hence it is that you require to put so large an amount of such unconcentrated manure on the land. There are other manures which contain a much larger proportion; for example, guano, various kinds of night-soils, and urines. Numerous experiments in my laboratory give an amount of nitrogen, in guano, equal on an average to seventeen per cent. of ammonia. Now, nitrogen, either in the form of ammonia or of nitrates, is the most important and expensive element of manures. Ordinary Peruvian guano has likewise from eighteen to twenty-two per cent. of phosphate of lime. This is also valuable: it is, as you are aware, in the shape of superphosphate of lime, one of the best materials for the turnip crop. It has been well ascertained by analysis, that the turnip contains a considerable amount of phosphate of lime. When turnips have been put upon the land without the application of it, they have scarcely grown to the size of a radish; whereas, the use of a sufficient quantity of this substance has led to a crop of from twenty to thirty tons per acre. It is, therefore, on the presence of ammonia and phosphate of lime that the value of manure principally depends; and when we know the quantity of those articles which exists in any given case, we shall be capable of forming a tolerably good estimate. You may reckon the price of ammonia, in guano and other substances, at sixpence per pound. Most chemists have given testimony to this effect; so that if you only have an analysis of guano, and divide the number of pounds of ammonia per ton by two, you will get the price in shillings, and will thus obtain the actual value of the ammonia.

The value of phosphate of lime may be stated at three farthings per pound, in some cases it may be a little more; but, if any person should pay three farthings per pound, he would, I think, have no reason to complain. As to the other constituents of guano, it is very easy to ascertain their value. We all know what is the price of salt in the market, and if we find that a certain manure contains four per cent. of salt, we may, of course, easily calculate what that amount is worth. It cannot be necessary that I should dwell on this point. Sulphuric acid also is found in guano and other manures; and, there again, it is not difficult to form an estimate of value. We must not, however, take the price of the highest compounds when we make our calculation, but must take some substance containing sulphuric acid, as sulphate of lime or gypsum, which has a low price in the market. Gypsum is from twenty to twenty-eight shillings per ton, so that the small quantity of sulphuric acid contained in guano cannot be of great value. Without the slightest difficulty, therefore, I repeat, we can form a tolerably accurate estimate, for commercial purposes, of any ordinary manure. I do not say *absolutely* accurate, but sufficiently so for the purpose required, the composition being known, for of course, without such knowledge as that it is impossible to tell the value.

Now before leaving the subject of guano, let me just mention its origin and sources. Guano is obtained from deposits of the dung of birds which have fed upon fish. It is not confined to any one quarter of the globe; it is not limited to South America, but it is found in all latitudes where great flocks of birds congregate and deposit their fæces, and where the rain and wind do not carry these away. In many places this manure is now being collected by hand. Instead of its being allowed to accumulate for a number of years, persons are employed in gathering it year by year; and it is now being deposited in many places to a sufficient extent to render this process of collection very profitable. The newly-deposited guano is found to contain in some instances more than twenty per cent. of ammonia. As regards the guano found in the island of Chinca and in other islands on the coast of Peru and Bolivia, these have been deposited for ages. Hundreds of years ago, guano was used in Peru in the cultivation of the soil; and it always secured exceedingly good crops. It is, in fact, merely the fæcal matter of birds. This natural substance must vary considerably in its composition. Where there has been little or no rain, you have it in a state of purity; but on the islands to the north or south of the dry latitudes it is found more or less deteriorated by water; the soluble materials are in that case lessened in amount, the ammoniacal salts are to a great extent washed away, and the proportion of insoluble materials is increased. This effect is palpable in the case of the Saldanha Bay guano, in which, instead of fourteen or sixteen per cent. of ammonia, you have one and a half or two per cent., and fifty to sixty per cent. of phosphate of lime,—a substance not very soluble in water. It is, then, quite clear that guano from different quarters of the globe differs very much according to the influences to which it may have been exposed. Even guanos obtained from the same island may differ in quality. Those which have been most exposed will be found of less value than those which have been covered up and not subjected to atmospheric action.

Ammonia and the other soluble compounds of nitrogen act on plants in a very similar manner, and producing, as they do, a very great luxuriance of growth, they require to be used with prudence and judgment, especially in the case of corn crops. Many farmers have suffered great loss from the use of too large quantities of guano, or of nitrate of soda, on wheat and barley; the corn having been lodged before harvest, and the crop in many instances totally spoiled. With grasses and other plants which require luxurious growth, these manures may be used with advantage to a much greater extent, and the increase of weight in the crop will be almost always in proportion to the amount of *nitrogen* in the manure,—supposing, of course, that the land is well supplied with mineral ingredients. Kuhlmann made some very interesting experiments on grass land, where nitrate of soda and sulphate and other salts of ammonia were applied in known quantities. The result was, that the increase in the crop was always in direct proportion to the nitrogen applied—that is, twenty pounds of nitrogen per acre, whether applied as nitrate of soda or as sulphate of ammonia, gave double the increase of ten pounds of nitrogen per acre. This is an important fact, and advantage should be taken of it for increasing the quantity of green food, and consequently the amount of stock upon our farms. As common salt has a direct tendency to strengthen the straw of our grain crops, it may be very judiciously used for that purpose with guano and nitrate of soda. The chances of the corn lodging are thereby greatly decreased. A mixture of four hundred weight of salt, and from three quarters to one hundred weight of nitrate of soda per acre, will be found an excellent spring dressing, on light lands, for sickly-looking young wheat, or for barley. About two hundred weight of Peruvian guano and four hundred weight of salt are also an excellent dressing for the heavier descriptions of soil.

One of the best known artificial manures is, I need hardly say, bones. That bones must be beneficial as manure will appear from a very simple consideration. Animals are fed upon vegetables, and the whole of their bodily structure grows out of the food, or is eliminated and formed from it. If the food did not contain phosphate of lime, the bony structure of the body could not be built up: if the soil in which vegetables grew did not contain phosphate of lime, the seeds of vegetables could not be matured. Supposing the arable land of this country to have been robbed for a thousand years of phosphate of lime, and never to have received any back again; supposing this article to have been continually exported in the shape of milk, cheese, sheep, and oxen, it is clear that unless the land had almost an unlimited amount of phosphates, which we know is not the case, there must have been a proportionate diminution in the quantity of these materials. Hence it is, that when certain substances which had been taken out for a long period have been again suddenly applied, land which was hardly worth five shillings an acre has sprung up to the value of fifteen shillings, and there has been an enormous increase of crop. For a long period, for example, we had been robbing our land of gypsum; and when this material was first brought into use, and applied to the soil, almost miraculous results followed. So, likewise, on the first application of properly-ground bones in this country, the effects were quite marvellous. Bones are valuable for two reasons—on account of the phosphate of lime they contain, and on account of the nitrogen, which becomes ammonia as the bone decomposes in the soil. Some chemists assert that bones contain six per cent. of nitrogen; but that has not been the result with any of the bones that I have analysed: probably four per cent. would be nearer the mark. I may as well mention the adulteration of bones at once: I shall afterwards have to speak of the adulteration of guano. Bones are not received by you in their original and entire state, because they would in that case be of little use to you. As farmers, you do not possess mills for the purpose of grinding them, and you are therefore obliged to entrust other persons with the work of reducing them to a proper state for the land. Now it would be well if parties who ground bones ground nothing else; but it does so happen that a great many other things are ground up with them, in order that farmers may buy an adulterated article, apparently at a much less cost, but in reality at a much greater, than that for which they could buy a genuine one. I speak from my own personal experience, when I assert that the bones ground in London, and in many other places, are often mixed in large quantities with oyster-shells. These oyster-shells have the property of splitting up into nice fragments, and unless a gentleman takes out his glass and examines them curiously, with the view of discovering bits of mother-of-pearl, he will probably be unable to discover that he has bought a spurious article. There is frequently from twenty to twenty-five per cent. of this adulterating material; and, of course, so long as farmers will patronise dealers without reference to character, and make price the sole consideration in purchasing, so long must they expect to get oyster-shells instead of bones. But this is not the only material which is used in adulteration. Soap-boilers' waste and sandy and earthy matters are also introduced. Oyster-shells and soap-boilers' waste contain large quantities of carbonate of lime. If, therefore, the farmer makes his own super-phosphate of lime, he will experience a double loss; for, until all the carbonate of lime has been acted upon by the acid, no super-phosphate is formed. As carbonate of lime, or chalk, requires about its own weight of sulphuric acid to drive off the carbonic acid, it follows that bones adulterated with twenty-five per cent. of oyster-shells or waste would require five hundred weight of extra acid per ton of bones to neutralise the lime before any super-phosphate could be formed.

Now there is another manure which has lately come into use, or at least has been brought prominently before the public —I refer to peat charcoal. We have had a few trials of this material, though not enough to give evidence of all its properties, and to show how far it is available for agricultural improvement. Probably, however, it will prove a very valuable adjunct, and will be extensively used, if it can be supplied at a reasonable rate. This charcoal has, like charcoal generally, a considerable power of absorption. It may be applied to sewage with good effect, as it arrests the escape of noxious gases. But in the use of it in connection with night-soil, there is one thing which it is especially necessary to bear in mind, namely, that some sulphuric acid should be mixed with the charcoal when removed, as there will otherwise be a slow escape of the ammonia previously absorbed. This is caused by the gradual action of the air, which replaces the ammonia in the pores of the charcoal as the watery vapour is driven off; and it would be very easy to stop this action by means of a certain amount of sulphuric acid. It is difficult to calculate the value of night-soils and urines, because of the great quantity of water contained in them. If you could get them in a dry state, they would perhaps be the most valuable substances in the world; if you could by any means, such as passing the urines through charcoal, get rid of the aqueous material, they would answer very well; but it is difficult to do that merely by mixing them with charcoal. From experiments which I have tried, it is perfectly clear that a certain quantity of peat charcoal, having urine filtered through it, will, when dried with sulphuric acid, retain from four to five per cent. of ammonia, which would constitute it a valuable manure. There can be no doubt that if this substance were put under our friend Mr. Mechi's sheep or bullock lattice, and if the fæcal matter were allowed to pass through the lattice, and fall upon it, such a carbonised manure would be found of great benefit to the agriculturist. I must, indeed, distinguish this carbonised material from mere organic matter, which has not the same power of absorption. If you took one hundred weight of straw and carbonised it, it would afterwards have a much greater power of absorption than it had while left in its natural state.

I will now speak of the nature and extent of the adulterations to which guano and similar substances are exposed. We have seen clearly that the value of guano and other artificial manures depends pretty much on their ammonia and phosphate of lime; it cannot depend on a given amount of sand, or loam, or brick-dust, or ground tiles, or any article of that kind, which may be mixed with it; and it is one main object of my lecture, to bring palpably before the practical farmers present a glimpse of the fearful extent to which adulteration is now carried, though it must be very inadequate when compared with the reality. I feel perfectly incapable of showing one hundredth part of the actual extent of this evil. Gentlemen, you are robbed systematically. It is not simply that a little country dealer buys his ten tons of guano, mixes some foreign matter with it, and then sells it as genuine; there are men who make hundreds and thousands of tons of materials for adulterating guano, which are sold in the market for the express purpose of adulteration. It is a general system, beginning in the metropolis, and extending over the whole country. Even the country cheaters are themselves cheated in turn. The men who come to London to buy their manures very often get an adulterated substance; the article passes through the hands of half a dozen parties before it reaches the farmer, and when at last it does reach him, it is in an extraordinary state of adulteration, very little indeed of the original matter being discoverable. Guano ought not to contain more than one and a half to two and a half per cent. of sand; besides which there should be at least twenty per cent. of phosphate of lime, from sixteen to seventeen per cent. of ammonia, and a considerable quantity of organic matter. Now you can buy guanos in the market, containing from sixteen per cent. of ammonia, which is a good genuine article, down to others containing only a trace. It grows "small by degrees, and beautifully less," until you have got a thing which contains little else than our good Essex marl, from the Wanstead Flats, or some other place, with a little guano mixed with it to give it the right smell. Another adulterating substance is ground marl from Bow Common.

In fact, the whole system of adulteration is so well devised, that, without an analysis, it is almost impossible for the farmer, or the ordinary country dealer, not to be imposed upon. In some cases the buyer has seen his guano taken from the ship's side, and has congratulated himself that he was too cunning to be taken in; but, unfortunate man! he had quite overlooked the Essex marl or ground tiles concealed in the barge that it might be well mixed with the guano as it went up the river to the appointed wharf. Some parties have three or four wharves for shipment in various parts of the river, and the same adulterated material is often sent even to the same buyer as two or three separate guanos at different prices. Of course those purporting to be different are shipped to the buyer from different wharves. The two following analyses will give some idea of the adulterations carried on in the manure market:—No. 1, came into the London market, per ship, from Liverpool. It was offered for sale by sample, in some places as Peruvian guano, at £6 10*s*, to £7 per ton: in others, as Saldanha Bay guano, containing sixty per cent. of phosphate of lime, at £4 to £5 per ton. The samples were contained in bags of blue paper, purporting to come *ex* some ship from Valparaiso. About one hundred and fifty tons were brought into London, the greater part of which found its way to the farmers of Hampshire, no doubt to their great edification and benefit. No. 2 was offered for sale as Saldanha Bay guano, at £3 or £4 per ton.

No. 1. Guano. (?)

Gypsum	74·05
Phosphate of lime	14·05
Sand	2·64
Ammonia	0·51
Moisture and loss	8·75
	100·00

No. 2. Saldanha Bay Guano. (?)

Sand	48·81
Phosphate of lime	10·21
Gypsum	5·81
Chalk	22·73
Moisture	12·44
	100·00

Now I will exhibit here a few of these samples of counterfeit guano, for the way in which they are got up for sale is really very ingenious. I want the opinion of some of the best-informed gentlemen here as to which of these samples is the best. [Mr. Nesbit then handed to the Chairman specimens of two kinds of guano, requesting him to state, after examining them, which he would pronounce the best. The Chairman having selected the one which he conceived to be the best, the Lecturer continued.] Well, now, this which our Chairman has selected as the best guano, is the one which is adulterated; and it contains nearly half its weight of Essex marl. [The Lecturer then exhibited in a bottle the proportion of sand to genuine guano in the two samples, showing that in the guano which the Chairman had considered the best, the sand and other worthless insoluble materials constituted more than one half of the whole.] In the guano which our President thought best, there is 52.8 per cent. of sand, though it was sold as genuine.

The mode of mixing this sample is clever and peculiar. The whole of the guano and marl are not mixed together at once, but the large lumps being picked out of the genuine guano, the small is thoroughly mixed with the marl, and then the unbroken large lumps of guano are carefully added so as not to break them. The whole, therefore, has very much the appearance of good guano; for the lumps in the mixture are merely the guano unadulterated. Here is another specimen [exhibiting it], in which I found 54 per cent. of insoluble matter. Let me now show you the proportion of insoluble matter which is contained in genuine guano. This contains only eighteen grains in one thousand, or 1.8 per cent. Remember, gentlemen, in future, that the strongest-smelling guano is not always the best. You cannot tell whether or not it be genuine either by the smell or by the colour. In fact, the only means by which you can ascertain the truth of the matter is by analysis. I will, however, show you one mode of detection which will serve your purpose so long as the adulterators continue to act upon the present system. They now adulterate with a heavy article. If you take five hundred grains of the best guano and five hundred of an adulterated article, and put each into a tube of the same size, you will find the adulterated article much lower in the tube than the genuine one. Here is an illustration. [The Lecturer here exhibited two tubes, containing respectively the same quantity of adulterated and genuine guanos, the latter reaching far higher in the tube than the former.] The presence of the sand is shown at once by the comparative smallness of the space which it occupies.

I must now show "THE ARTICLE" itself—the material for adulteration—it is known in the trade as "THE ARTICLE." It can be bought for the purpose of adulteration at from 10*s*. to 20*s*. per ton. There may, perhaps, also be ten or twenty per cent. off for cash. I hold in my hand, gentlemen, five hundred grains of "*the* article." [The Lecturer here exhibited in one tube five hundred grains of "the article," and in a similar tube five hundred grains of genuine guano.] You see "the article" presents a very sorry appearance by the side of the genuine guano. Observe the amount of silica which it contains, and then judge what is the extent of adulteration. I must, if possible, compel the attention of all present to this wholesale system of adulteration. It is not, you see, confined to one or two small houses, but the trade in this article is as regular a branch of business in the metropolis as the trade in guano itself. How does this arise? Whence comes all this adulteration? It is partly owing to the fact of the farmer's nibbling and haggling to get the last penny of profit out of the dealer's hands. He has thus been compelling those who would perhaps otherwise be honest, to sell an article like that which I have been exhibiting.

This is not buying in the cheapest, but in the dearest market. Let me here observe, that it is quite impossible for persons who have once begun to adulterate to do so to a small extent. No man can adulterate merely to the extent of ten per cent.; it would not pay. In the first place, an article has to be purchased and worked up, and made to look something like guano; then there is the mixing of this article with the guano. The whole process is expensive; and every particle of the cost, with a large profit superadded, must be paid by the farmer who buys the adulterated article instead of the genuine one. The probability is, that he does not get in return for his money more than one fourth or one third of guano; but all the rest is sand, or ground tiles, or loam, the carriage of which is, of course, another item of cost to the farmer.

I have often remarked that if it were possible for chemists to concentrate manures so that they would be worth even £50 a ton, it would be an immense advantage to those who have to use them. If guano, for example, could be concentrated four-fold, it would for that very reason be the most valuable manure the farmer could use; since, being of small bulk, the cost of carriage would be decreased four-fold. To return, however, from this digression. I was observing that it would not answer a dealer's purpose to adulterate to the extent of ten—I might even say twenty—per cent.; nor, indeed, do dealers confine themselves to such a small proportion. These adulterated manures are sold, some at £5, some at £6, some at £8 per ton. The best of them are adulterated more than forty per cent.; and in many cases the adulteration is as much as sixty or eighty per cent.

It remains for you, gentlemen, to attempt to put a stop to this imposition. I can scarcely offer any other practical means of detection than that which I have just mentioned—that of observing and comparing the different degrees of specific gravity or bulk of the samples. Let me tell you, too, that even if you do buy of a first-rate party, it is still possible that you may be deceived. I will quote Dr Anderson's opinion on that point; and the extract will show that even parties who wish to sell a genuine article are often misled. In an article on guano, in the "Royal Highland Society's Journal," he says:—"All the risk and uncertainty to which the farming public is now subjected might be avoided, if buyers would give up seeking for cheap guano, buy from dealers of character, and insist on their purchase being guaranteed of the same composition as a sample analysed by some chemist of known accuracy. It must, however, be distinctly understood that all these precautions are necessary, for there are such things as selling guano by fictitious analysis; and I have known instances in which dealers of the utmost respectability, and altogether above the suspicion of fraud, being in the habit of selling guano without analysis, have bought in the same way, and have become the unconscious instruments of introducing a grossly-adulterated article into commerce."

I say, then, that even respectable parties may be deceived. There are gentlemen in the trade who would, I believe, scorn either to adulterate or to sell an inferior article as the best; but even these gentlemen may be deceived. Still one way in which you should endeavour to secure yourselves is by dealing with first-rate men—men who have a character to lose, and who are not, therefore, likely to adulterate. At the same time, I must confess that I see no effectual security except that which consists in your having samples of the bulk you buy analysed. Look at Scotland. The Scotch farmers have their samples analysed, and the bulk tested; and they have often recovered damages when the two have not corresponded.

Other manures are also adulterated in similar ways. Nitrate of soda is mixed with a well-prepared sulphate of magnesia, or Epsom salts, whose crystals are almost undistinguishable by the eye from the crystals of nitrate of soda. Sulphate and other salts of ammonia are also much adulterated. There are, in fact, a thousand ways of adulterating manures; and you can scarcely ever be sure, under present circumstances, that you are applying to your land a really genuine article. Take superphosphate of lime. If you do not buy from a respectable house, you will be sure to have large mixtures: fifty per cent., and in some cases seventy-five, of worthless material being mixed with the genuine substance.

I have letters from various gentlemen, including Professor Calvert of Manchester, and Professor Anderson of Edinburgh, all corroborating the fact of the immense adulteration of artificial manures. They have all analysed samples of guano which have been highly adulterated. Professor Calvert informs me that he has analysed some which contained from seventy to eighty per cent. of sand.

I must now mention a recent attempt to obtain money from the public, of so presumptuous and ridiculous a character, that I hardly know how to allude to it; I mean the fertilising of seeds. Many years ago it was proposed to steep seeds of various kinds in solutions of manure, or to roll them in some manuring powder, which, adhering to the seed, would render good service in quickening its germination and promoting its early growth. There is nothing unreasonable in this, and in many instances some good has been done by the process. But within a few years, both here and in France, parties have come forward to do away altogether with ordinary manuring, and to give such a coating to the seeds as will carry them well through till harvest. Yes, gentlemen, your boasted farm-yard dung, your Peruvian guano, your superphosphate of lime, are now, by the "*discoveries of science,*" rendered wholly useless! Only put three or four pounds of a powder over the seed for an acre of land, and you may then, with your hands in your pockets, joyfully await the hundred-fold increase of a teeming harvest! Now, in the first place, I as a chemist should condemn the thing at once; and as to you practical men, I should think you must be of the same opinion as the Scotch farmer, who, when the laird remarked to him, "Donald, the time will come soon when we shall be able to carry the manure in our snuff-box," replied, "Yes, but when that time comes we shall be able to carry the crop in our waistcoat pocket." We have been told that most astonishing results have arisen in France from the use of fertilising powder on seeds. Being a corresponding member of the French Central Agricultural Society, I took the liberty of writing to M. Payen, who is one of the professors of chemistry in the Ecole des Arts et Métiers, and who was lately in this country for the purpose of inquiring into the state of our artificial manure manufactures. In reply to the letter which I wrote to him, that gentleman says:—"The exclusive use of a small quantity of powdered manure to envelop seed, would evidently be both dangerous and prejudicial to the true interests of farmer and landlord. I am authorised to add, that this is also the opinion of my friend Boussingault, and of my other colleagues, the members of the Central and National Society of Agriculture. Besides, the experiments already made in France, and duly controlled by Messrs. Moll and others, were not at all successful. The numerous publications favourable to this ridiculous system of cultivation without manure, do not deserve any confidence, for they were paid for by the speculators, and inserted in our gazettes as common advertisements, or publications of chimerical results."

So much for the opinion of the French savans; and I apprehend that if it has not answered in France, it will not in England. If, indeed, we could concentrate the virtue of twenty loads of farm-yard dung into one pound, it would be an excellent thing for the cause of agriculture.

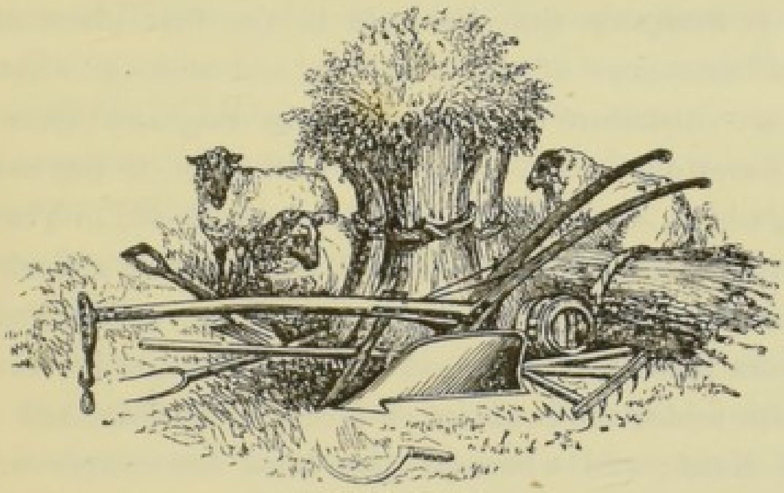
But now for the analysis of this precious manure, for which I paid at the rate of twenty shillings for four pounds and a half, or at the moderate and unassuming price of £497, 15s. 6¼d. per ton! The very first thing which presented itself, was fifty-five to fifty-nine per cent. of carbonate of lime—or common chalk! I will give you the full analysis.

Composition of a sample of Fertilising Powder, at the price of twenty shillings for four pounds and a half weight.

Silica	6·45
Moisture	4·91
Organic matter	25·79
Nitrogen	1·47
Carbonate of lime	55·59
Potash and soda	0·92
Sulphate of Lime	1·71
Iron not determined	—
Phosphate of lime	0·96
	97·80

You must all consider the article too dear at the price.

Now, gentlemen, I have thus brought before you the nature and extent of adulteration. My main object this evening has been that the reality should go forth to the agricultural world. I believe—in fact, I know—that there are parties in London who are making several thousands a-year by adulterating manures. The names of some of these men are scarcely known in the market, but what they manufacture finds its way to the land. It is not such gentlemen as yourselves who are chiefly exposed to this evil; you can protect yourselves; but there are many of the poorer class of farmers who are continually imposed upon without knowing it, because they endeavour to buy two tons of guano for £13, instead of being contented with one ton for that amount. I have placed the matter before you, because I think it ought to go forth to the agricultural world that farmers are being systematically and regularly cheated; that they are imposed upon in this matter; that they are constantly buying sand for guano, and oyster-shells for bones; that they are not merely cheated here and there, but that parties make it their business to manufacture THE ARTICLE for no other purpose than that of mixing it with manure. When all this is known, the remedy will lie in your own hands. In the first place, you should deal only with men who have a character to lose, and who will not endanger their position by anything like deception. In the second place, you should not neglect to avail yourselves of the security afforded by analysis. The facilities for obtaining an analysis are much greater than they were, and it is now very easy to get manures analysed at a trifling cost, and thus to ascertain whether they are genuine or not. If agriculturalists generally were vigorously to pursue this plan, I believe its necessary effect would be to put a stop to adulteration, to drive the dishonest dealers from the market, and to leave the manure trade in the hands of honest and honourable men.



THE USE AND ABUSE OF LIME IN AGRICULTURE.

The use of lime in agriculture has been known from the remotest ages; and the relation of the different kinds of limestone, and the composition of lime and its action in the soil, are matters on which a book might be written with much greater facility than a lecture can be delivered so as to embrace the leading points. As, however, I have only a limited period for introducing the subject, it must be my endeavour to place before you its salient features as concisely as possible.

Now, it is desirable that I should in the first place describe the principal limestones of this kingdom, and state in what directions they are distributed. We have in England three great divisions of limestone rocks. The first formation, to the eastward, is the chalk, which, beginning at Flamborough Head, in Yorkshire, proceeds south-westward to Dorsetshire, and, making a small bend, performs the circuit of Kent, Sussex, Surrey, and Hampshire, stretching from Beachy Head round to Folkestone and Dover. This chalk also dips under the counties of Norfolk, Suffolk, and Essex, and part of Kent; and wherever you bore downwards in those counties which lie eastward of the chalk, you come to the chalk again. You have then, from the Wash and extending right through the fens of Cambridgeshire, a soft clay; in fact, the very indentation of the country in that direction is owing to the soft clay intervening between the chalk and the oolite. Passing to the westward of the fens, you have the oolite formation, which in its various characters extends from the Yorkshire coast near Scarborough, through Rockingham Forest in Northamptonshire, to the Cotswold Hills, and terminates in the sea at Bridport, in Dorsetshire. The oolites contain three varieties of limestone. First, there is what is termed the Portland oolite, found chiefly in the Isle of Portland, but of which a little is found near Aylesbury. Then there is the middle oolite; and there is, moreover, the inferior oolite found largely near Bridport. All these oolites furnish very good lime. After these, there is the great development of mountain limestone which is found so extensively in Northumberland and Durham, in the Western parts of Yorkshire, in that part of Derbyshire which is called "The Peak," and in other districts further to the south. I now come to the next division of limestone, that which is found near Torquay and in certain parts of Exmoor. This species of lime is not very largely developed in this country; but it exists in two or three places, and, fortunately, just where it is most wanted. We have also in the old red sandstone, or Devonian system, the cornstones or nodular masses of limestone found in Herefordshire, which make very good lime. We have, lower in the series, the Silurian limestone, which is very much developed in some parts of Wales, and is also found in large quantities near Dudley; and many persons present have, perhaps, seen the substance which is called "Dudley limestone." The same formation is also found in an adjoining county, Shropshire, where it is known under the name of "Wenlock limestone." There is, also, the primitive limestone found in some parts of Devon and Cornwall; and, to complete the catalogue, there is the shelly limestone of the Wealden formation, between the chalk and the oolite, found at Bethersden, Kent; Petworth, Sussex; and in the Isle of Purbeck, Dorset. These, then, are the principal divisions of limestone; and let me observe that they are so distributed on the whole as to leave very few parts of the country without the advantage of being able to obtain a supply of this valuable article within the distance of a dozen or twenty miles.

Having mentioned the distribution of the several formations, I will next proceed to speak of their composition. Limestones have been considered by some persons valuable in proportion to their purity; that is to say, in proportion to the absence of anything else but carbonate of lime. You are aware, I presume, that limestone is itself a carbonate of lime:—in its pure form it consists of twenty-two parts of carbonic acid and twenty-eight of lime. When limestone is heated in the furnace, the carbonic acid is driven off, and pure lime left behind; that is to say, it would be pure if the limestone itself were pure. I was remarking that it has been supposed that the purest limestone is the best. I shall now endeavour to prove to you that such is not the fact, but that impure limestone—that is to say, limestone containing other substances besides carbonate of lime,—is that which is best adapted for agricultural purposes. There are, in fact, no limestones found absolutely pure; all contain a certain amount of moisture, silica, iron, alumina, phosphate of lime, and even a little sulphate of lime. It is perfectly clear that limestones must be the better for any phosphate of lime which they may contain. As you are continually putting into the soil bones and other substances, because they contain phosphate of lime, it is evident that those limestones which contain the largest proportion of phosphate of lime are the most valuable, supposing the other constituents to be the same. We have analysed in our laboratory, some hundreds of specimens of limestones: none were found free from phosphate of lime, while probably the average proportion of it was one per cent. Many limestones contain much more than one per cent.: some contain as much as three or four; but, supposing them to contain on the average one per cent. of phosphate of lime, in that case ten tons of limestone, or its equivalent of five or six tons of lime, put on the land, would furnish two hundredweight of bone earth per acre, which I need not tell you would be a considerable dressing, and would, for years afterwards, prove advantageous to the soil. Well, then, many limestones also contain silica in a soluble state, so that when put on the land it is easily acted upon, and, in fact, disintegrated; and I think it very probable that a limestone which contains a certain amount of such a substance as silica, in a soluble condition, is preferable to what is termed "pure limestone." Many also contain sulphate of lime or gypsum, and even these are better adapted for general use than such as approach nearer to a state of purity.

You will thus see that my opinion upon this part of the subject is, that it is not the purest kinds of limestone which are calculated to confer the greatest benefit upon the farmer, but that those which contain a certain amount of what are called impurities are the best adapted to agriculture, because they convey to the soil other constituents besides the calcareous matter.

It would be impossible for me, within the limits to which I am restricted, to give you a distinct idea of all the different kinds of limestone. Indeed, I may remark, that the subject has not been sufficiently investigated to enable me to enter into it as fully as I could desire, and it would require much more time than I have had at my disposal to make the necessary analyses. I had intended—and if my lecture had been postponed for a twelvemonth, I should probably have been in a position—to bring under your notice the results of the analysis of some of the chief limestones of the kingdom; but as the task of analysing would occupy three or four months, you may easily conceive why I have not been able to execute the whole. Speaking of the chalks generally, however, I may say, in the first place, that we have three distinct kinds, the upper and the lower, and the chalk marl, and that they are distinguished by the fact of the lower chalk containing a greater amount of silica and phosphate of lime, and being more easily acted upon by frost, than the upper chalk. The chalk marl, beneath the lower chalk, contains a greater amount of phosphate of lime than either of the others, and wherever that is put on the land, great benefit is derived from it. The next limestone which I shall notice is the Weald limestone. It is of fresh-water formation—that is to say, the shells which are found in it are fresh-water shells; and it is found at Bethersden, in Kent; at Petworth, in Sussex; and in the isle of Purbeck, in Dorsetshire. It is the kind of limestone which was used, during the reign of Henry I., in laying the foundations of old London bridge. Besides carbonate of lime, it contains about twenty per cent. of other matter; and when properly burnt into lime it proves very valuable to the land. The next limestones are the oolites, well known at Pickering in Yorkshire, at Northampton, at Higham Ferrers, and in various parts of the country. These limestones contain, amidst a quantity of other matter, three quarters per cent. of phosphate of lime. The next class are those of the lias, which are found in nodular masses about Whitby and Lyme-Regis, and in other parts of the country, and which are generally sent to London to make cement. Below the lias limestones we have the mountain limestone, which is well known in Derbyshire, particularly at Crich Cliff. Many of you may have observed a number of limekilns, in passing by railway, just where you turn off for Matlock. The lime of this district is very good, and is sent for miles to be used for agricultural purposes, for which it is found extremely beneficial. Next, there is the limestone which is found at Dudley, near Birmingham. That formation has been pushed up by volcanic action; having thus been obtruded into a spot which it would not otherwise have occupied. Some parts of this limestone are very pure, and other parts contain a large proportion of foreign matters; and I should certainly choose the latter for agricultural purposes, but the iron-masters would of course prefer the purest. We then have the limestones of Devonshire, which, generally speaking, are tolerably pure.

I must next refer to the use of lime, and, in doing so, it will be necessary for me to allude first to the practice of chalking or marling. It has been found that the use of marly substances, containing calcareous matter, is equivalent to the use of lime itself. It does not seem to make much difference, generally, whether you use calcareous matter merely in the state of carbonate of lime, or use chalk disintegrated by frost, or whether you use quick-lime itself. Although there has been a great deal of dispute on the point, yet I do not think the experience of farmers has proved that there is much difference in the result between the use of quick-lime, or marls, or of soft limestone disintegrated by the action of the air. And, indeed, I do not see how there can be much difference. If hard limestone is burnt into lime, when it has absorbed moisture it becomes a very fine powder, a finer one than could ever be produced by mechanical means. This powder, or slaked lime, absorbs the carbonic acid of the atmosphere, and again becomes the same carbonate of lime that it was before being burnt. But its mechanical condition is now entirely changed.

Instead of being a hard solid mass, it is a white friable powder. Burning is chiefly useful in the case of hard solid limestones, because by that means they are reduced to a powder, and in this state they will readily act upon any substance in the soil. Many persons have supposed that caustic lime exerts a great and peculiar action in the soil, but to me this appears very doubtful. The chief use of burning hard limestones is, in my opinion, that it reduces them to that minute state of division in which they act most readily on the soil. I am not at all singular in this opinion. Nearly all chemists who have investigated the matter, have, I believe, declared that lime in its caustic state, does not exert any peculiar action, but that it is in the state of carbonate of lime that its peculiar influence is witnessed.

We are then led to the conclusion that the same result is obtained from marling, from the use of the easily disintegrated chalk, and from the application of the harder limestone when burnt. The effect differs only in proportion to the solubility or non-solubility of the limestones. If these be very solid, or if the marl containing limestone be not easily acted upon by the air, you will not find those particular substances produce so immediate an effect as others which contain the calcareous material in a more soluble state,—that is to say, more minutely divided. These marls, as I before intimated, will also vary in their operation according to the quantity of phosphate of lime, silica, alumina, and other substances of the same kind, contained in them. Although carbonate of lime be the chief material, yet its action will be modified by that of others with which it is connected.

You perceive, then, that limestones may be regarded in two distinct points of view,—first with reference to the action of the calcareous matter considered as pure, and secondly with regard to the action of the materials with which it is connected.

Having disposed of the latter part of my subject, so far at least as my limits will permit, let me now proceed to speak of the action of calcareous matter in the soil.

Lime, whether in the caustic state or in the state of carbonate of lime, has a distinct action on the mineral ingredients in the soil. In our chemical analyses, if we want to liberate potash and soda from an earth, we heat it red hot, in a crucible, with lime; after which operation we can get all the potash and soda from the soil by the action of water alone. Even if we merely mix a quantity of soil with some lime and water, so as to make a kind of milk of it, and leave it for five or six months; at the end of that time, on filtering the liquid, we shall find a considerable amount of alkali dissolved out of the soil. In like manner, when you put a quantity of lime on your land, and allow the atmosphere to act upon it, the rains dissolve it; it becomes intermixed, and, as it acts upon every portion of the soil with which it is in contact, a considerable amount of alkali, which is necessary for the growth of plants, is liberated for that purpose.

But lime acts powerfully not only on the mineral, but also on the organic matters in the soil. And this is the great point which I shall have to illustrate to-night, namely, that lime, when used in the soil, acts materially on the organic matters therein contained. All good soils contain a considerable amount of vegetable matter, or have the power of absorbing from the air substances adapted to the formation of vegetable matter.

When you have lime in the soil, whether it be put there in the state of lime or in that of carbonate of lime, you have at once a determinate action on the organic matters, and also a greater power of absorption from the air. You have the decomposition of roots and plants and other vegetable *débris* very much augmented by the presence of the carbonate of lime. These substances are not able of themselves to decompose with sufficient rapidity to furnish the greatest available amount of nutrition to the growing crop. There can be no quick decomposition, for the simple reason that the substances which would be produced by decomposition would find nothing with which they could unite; but in carbonate of lime you have a substance with which the different vegetable acids formed in the various phases of decomposition can unite at once. It is a fact well known to every gentleman here, that it is on soils which contain a great amount of organic matter, or which have not been under plough for a great many years, that lime produces the most marked effect. If you have worked your land for many years as arable land ; if you have ploughed it, and sown it, and reaped crops from it to such an extent as materially to have affected the organic matter of the soil and the stores of ammonia which it has absorbed from the air, lime will do little or no good. But if the case be otherwise, you will find lime produce the very best effects, because it immediately brings the stores of nitrogen and the organic materials in the soil into the best possible state for plants to act upon them. I may mention also that the action of lime is very effectual in peat soils and in soils which contain sulphate of iron, where it is useful in correcting what is called "sourness," an evil which I need not tell you is to be found in many districts. It can scarcely be necessary to mention, that the soil, in order that lime may be useful, must have been previously drained ; without that it will be perfectly useless, drainage being essential to enable lime to percolate through the soil and perform its proper functions.

There is another action of lime in the soil to which it is necessary for me to allude. You are well aware of the existence of what are called nitre beds. You know that in the time of Charles I., of Cromwell, and of Charles II., saltpetre was manufactured in this country in a rather peculiar manner. Patents were granted to persons to go and dig under old stables for the soil they could find there, and to get the mortar from old buildings, etc. ; and out of such materials was saltpetre produced. The process was very simple and very effective. During the whole course of the French Revolution the saltpetre used by the French army was obtained in a similar manner. A quantity of chalk or other calcareous matter was laid up in heaps alternately with farm-yard manure. First, there was a quantity of manure, then a layer of mortar or other calcareous matter, then some more manure, then some more mortar, and so on. All this was watered with urine or with some other liquid; if urine could not be procured, pure water was used. The whole was kept under cover in a tolerable state of moisture, and turned every three or four months. After twelve months no more urine was added, but water only. At the end of eighteen months the whole mass was put into a tank of water and well stirred. After a time the water was pumped off; and in it the whole of the ammonia and nitrogen of the manure and the urine was found as nitrate of lime. All the nitrogen of the manure was converted by slow oxydation into nitric acid, which united with the calcareous matter to form a nitrate of lime. This solution was subsequently mixed with wood ashes, which contain carbonate of potash; and by double decomposition there was formed carbonate of lime, which precipitated as a white powder, and nitrate of potash (saltpetre), which was then crystallised. In this way was made nearly the whole of the saltpetre used by Napoleon during his protracted wars.

Gentlemen, what took place in the saltpetre beds in France is taking place in your saltpetre beds—your fields. If your fields are properly drained, that they may absorb valuable materials from the air, and if they contain the proper amount of calcareous matter, there cannot be the slightest doubt that the same process will go forward. Beyond this, it is an undoubted fact that more saltpetre is derived from nitre beds than is equivalent to the nitrogen contained in the manure and urine added to them; that is to say, that the air acts in some way upon these beds, and that there is an absorption of nitrogen by them from the air. Under the influence of the slow decomposition of the vegetable and animal matters, nitrogen and ammonia are undoubtedly absorbed. If that be the case—if you have a proper amount of calcareous matter in your soils, and a proper amount of organic matter, you will find them not only producing nitre by their own decomposition, but likewise by absorbing similar valuable matter from the air; and this absorption will take place in proportion to the exposure of the soil by means of ploughing, and to the porosity produced by efficient draining, harrowing, and other similar processes.

There are one or two points deserving of notice in reference to the absorption of ammonia. I do not know whether you are aware that all soils contain a considerable amount of ammonia or nitrogen, in some form which is not yet perfectly recognised, and which does not seem distinctly adapted for the use of plants. We have ascertained in our laboratory, the amount of nitrogen contained in a number of soils brought from various parts of the kingdom; some being of the richest descriptions, and others yielding only a rental of from five to seven shillings per acre. We have found a very considerable amount of nitrogen in the latter, evidently not available for plants, but in such a state that it might be rendered available. This matter will probably form the subject of a communication to the Royal Agricultural Society, when we have completed the investigation. For the present, I only mention the fact that there is a very large amount of nitrogen in the soil, which might be rendered useful; for, if you use calcareous matter, you bring this material into distinct action, and make it capable of being taken up and absorbed by the roots of plants. You will see at once, by recalling what I have said, that if lime act distinctly upon inorganic matter, and if it act upon inert organic matter containing nitrogen, it is chiefly in the case of those soils which contain organic matters intermixed, and which have not been often ploughed or exposed to the air, that lime will be of material use.

All experience bears out this view. If a man has worked his land down to a low state, if he has been taking crop after crop, without much manure, and then fancies that by liming the land he can bring it back to its original state of fertility, he will find himself mistaken. It is upon land newly broken-up that lime tells best. In such a place as Exmoor, indeed, where the land has not been turned up within the memory of man, and where the soil contains only just enough lime for a chemist to certify, you will find the use of any other manure of no avail without lime. You may use guano, you may use bones, you may use anything you please of that kind, but not a single crop will you get, unless you also apply lime. In that part of the country, you can see to an inch where lime has been used. If you were to take a handful of slaked lime, and inscribe your name on the soil, you would, even three or four years after, be able to trace the exact spot where it was marked. I have myself observed on that moor, that in certain parts where lime has been used, the turnips were splendid; but the instant you passed the point up to which the lime had been applied, the crop entirely failed.

It is, then, my distinct opinion, that lime ought to be used on such soils as contain a large amount of organic matter—and, when using it on arable lands, never to trust to it alone, but to use other manures as well, though they ought not to be applied at the same time as quick-lime. You all remember the old proverb—

> "The use of lime without manure
> Will always make the farmer poor,"

—and that saying is perfectly true.

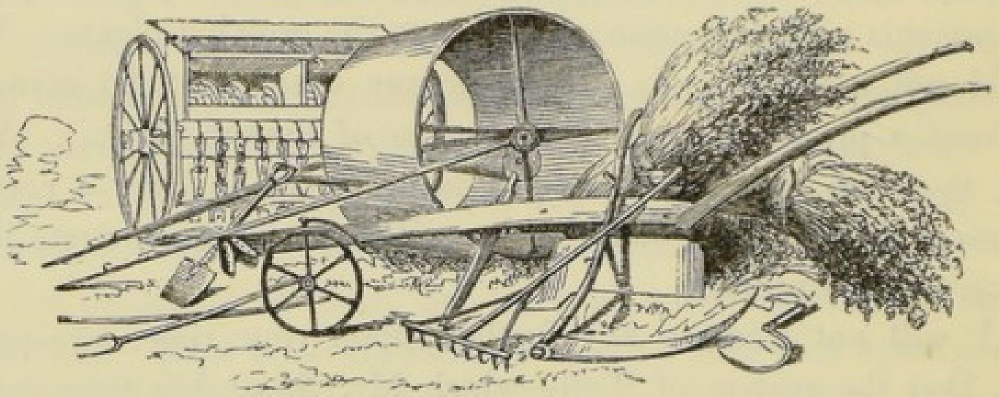
There is another action of lime which I wish to mention. You know, of course, that most limestones contain sulphate of lime. Rain brings from the air a quantity of carbonate of ammonia, which being a volatile salt, easily evaporates again; but if there be any sulphate of lime in the soil, the ammonia does not evaporate, because as soon as it comes in contact with the sulphate of lime, the carbonate of ammonia becomes sulphate of ammonia. A change takes place again after the superfluous moisture has evaporated from the soil, for the sulphate of ammonia re-acts on the carbonate of lime, and carbonate of ammonia is again given out. This is a very curious fact. I have here some chalk, and if I add to it some sulphate of ammonia, I shall form a portion of sulphate of lime; carbonate of ammonia will then be liberated, and may be easily detected by its odour. When soils are neither too wet nor too dry, but only just moist, carbonate of ammonia is liberated from the existing sulphate of ammonia.

There is another point which ought not to be omitted, as it is of considerable practical importance, namely, that there may be an almost entire absence of lime in soils resting upon limestone. I have found soils resting upon limestone—the Kentish Rag, for example—where the limestone has been within six inches or a foot from the surface, and there was not a thousandth part per cent. of lime in the soil itself. You know it is the constant tendency of lime to descend; the consequence of this is, that even soils which were formed by the disintegration of limestone itself, sometimes require liming as much as any others. I know that in Dorsetshire, Wiltshire, and some parts of Hampshire, farmers are absolutely chalking the Chalk Downs with manifest advantage; and both in those counties and in Kent, lime and calcareous matters have, on my recommendation, been applied with very great success upon soils resting on chalk or limestone.

There is yet another point which I wish to notice, namely, that without the presence of carbonate of lime in the soil, you can never have the full action of any description of manure. If there be sulphate of ammonia in the soil, you cannot suppose that it will be taken up into the plant as sulphate of ammonia; it must be decomposed before the ammonia can be absorbed. There is something required to unite with the sulphuric acid, and this is furnished by the carbonate of lime. There must, therefore, be carbonate of lime in the soil, and if you have that, you will have the sulphate of ammonia giving its ammonia freely to the growing plants. You could not usefully apply guano, or any other artificial manure, without a proper amount of carbonate of lime in the soil. You see, therefore, gentlemen, that it is necessary to have a certain amount of lime in any soil whatever, if you wish to cultivate it to the greatest advantage.

I will not trespass any further upon your time, except to say, that the system of Tull—which Mr. Smith has been lately bringing forward—is dependent upon the principle of the exposure of soils to the air. You must in this case have a proper amount of lime in the soil, or you can never have that proper absorption of manuring properties from the air upon which the system almost wholly depends.

The conclusions to be drawn from the few observations which I have had the honour to offer to you, are, I think, these: that lime can be used beneficially upon soils which have been little stirred, little exposed to the air—upon new soils, like those of Exmoor, or upon those which contain, naturally or artificially, a certain amount of organic matter—but that if used without manure upon arable soils, from which crop after crop has been taken, without any manure being added, it will not restore fertility, and that those farmers who are in the habit of putting large doses of it upon their land, trusting to that alone for good crops for six or seven years after, abuse this most valuable substance.



THE QUALITIES OF DIFFERENT KINDS OF FOOD, AND THE BEST METHODS OF FATTENING STOCK.

It will be necessary, in speaking of the best methods of fattening stock, to take into consideration all the causes whereby gentlemen who keep stock may sustain loss, or whence may arise a deficiency in the year's accounts; though I shall not be able to enter at all into the question of the markets, or of the buying and selling of animals. It will be my aim to bring under your notice the principles on which the fattening of animals depends; and I shall endeavour to point out the cases in which loss may arise, whether from the use of improper food, or from the want of good ventilation.

I must speak first of the constitution of vegetables, and of vegetable growth in general. Gentlemen, you all know that the vegetables which you grow are not like those with which nature clothes the fields. If you leave the bare surface of the land to the action of the atmosphere, and to those causes which are constantly operating, you find nature covering the fields with plants of her own choosing; and what you have to do, is to grow plants selected from the whole mass of those which she has presented to you. You single out certain plants for the purpose of obtaining the largest quantity of those substances which are useful for animal life. In doing this you reject the ordinary offers of nature, and make use of her powers with the assistance of art. Of course, you know very well that it is necessary that there should be a total change in the land, when you thus proceed to cultivate plants differing from those which are produced by it in its natural state; and to secure this, you add manures which tend to raise the produce to the highest amount.

The organic ingredients of plants, viz., oxygen, hydrogen, nitrogen, and carbon, are generally derived by plants from the action of the leaves on the air; but when you manure your land with common manures, you always have the roots of the plants taking up those substances from the soil as well. These are now absorbed by the roots of the plants, though in the wild state of nature they are generally taken up by the leaves only. Vegetables during their growth are continually taking up carbon, hydrogen, nitrogen, and oxygen, retaining the three first and freely casting out the last. In many plants, substances are often produced containing not a particle of oxygen; for example, otto of roses and many of the essential oils.

Having mentioned the process which is constantly going on in plants, I wish to show you that for the support of animal existence, the different vegetables produced may be divided into two classes, having distinct properties. I have mentioned four materials—carbon, hydrogen, nitrogen, and oxygen. In all the substances which are adapted for food, oxygen is still present—it has not been totally cast out; and we have the four elements which I have mentioned both in animal and vegetable matters. The common principles found in vegetables resolve themselves into two classes, one destitute of nitrogen, the other containing it. The former, to which I shall first refer, may be called the non-nitrogenous elements of food, or the elements of respiration and the producers of fat. Those bodies in vegetables which contain no nitrogen are, fat of any kind whatever, oil, starch, gum, mucilage, and various kinds of sugar. These bodies, I say, contain no nitrogen: they are merely adapted for the production of fat, or for the purposes of respiration. It is necessary to explain, however, that these materials are of use in keeping up the animal heat. We maintain the heat of our bodies by continually applying fuel—that is, food containing charcoal and hydrogen, and passing through our system the air taken in by the lungs, which acts upon the combustible parts of our food precisely as it acts in lamps and gas lights, where we burn carbonaceous substances by currents of air. Thus in our own systems, and in those of all warm-blooded animals, there is a considerable portion of food consumed for the mere purpose of keeping the temperature of the animal elevated above that of the air in which it exists. The portions of the food of animals which are especially employed for this purpose, are those which I have mentioned. They contain no nitrogen whatever; they add nothing to the nutritive powers of the food; they could not enable any man to take a greater amount of exercise than usual; in no way do they tend to build up or support the animal organism. They are used, in the first place, to supply the fuel for heating the body. We take in by every inspiration a considerable amount of oxygen, which, after acting upon the carbon and hydrogen of these non-nitrogenous materials, passes out again in a consumed state. Let me here mention the amount of carbon consumed each day by various animals. Man consumes, on the average, from 12 to 14 oz., and there is required for that consumption 37 oz. of oxygen; the horse consumes 97 oz., and requires 258 oz. of oxygen; and the cow, consuming 70 oz. of carbon, demands 186 oz. of oxygen. You clearly see, then, that our animal economy requires that a constant supply of heat-producing materials should be brought into the system, and that a constant supply of oxygen should be taken into the lungs, in order that the body may be kept at a proper temperature.

Now, after the temperature which is necessary for the animal economy has been arrived at, you have left the excess of food beyond that which the animal requires for heating purposes. What remains of the oil, the starch, the gum, the mucilage, and the sugar, after the necessary production of heat, is formed into fat. This excess of food nature places upon the muscles in the form of fat, in order that if the animal be subsequently, through any misfortune, deprived of food, its days of feasting may in some measure minister to the necessities of its days of fasting. Of course, under such an arrangement, it is essential, for fattening purposes, that the animal should be kept at a proper temperature, otherwise no fat can be formed from these materials. This is one of the points which it is necessary continually to keep in view; for it will be found of material importance in connection with practice, inasmuch as the variations in the amount of food required by animals, will depend in a great measure upon temperature. In proportion to the temperature which an animal has to keep up, or rather in proportion to the degree of cold to which it is exposed, will be the loss of the materials consumed in keeping up the animal heat. Therefore warmth is always equivalent to food. The less animals are exposed to cold and wet, the less will the elements of respiration be required to produce the necessary degree of animal heat, and the more food there will be left for the production of fat. Therefore, it is of immense practical importance to the pocket that fattening animals should be kept warm and well sheltered. I shall not now dwell on this point, as I intend to advert to it again. You will find what I have just said clearly illustrated by the different kinds of food required by men in different parts of the world. Observe the difference between the food required by the Hindoo in the tropics, and that required by the Esquimaux in the arctic regions. The Hindoo lives on rice, which contains a very small amount of carbon and hydrogen, the producers of heat, as compared with the fatty matters which are consumed by the Esquimaux. The Hindoo is content with a small amount of rice and milk every day, whereas the Esquimaux will eat two or three pounds of candles, and drink a quart or two of train oil at once, without experiencing any ill effects. An Esquimaux will even drink a quart of brandy without suffering any injury; and it is because the native of the northern climate consumes such large quantities of fatty substances, that he is able to go almost naked, notwithstanding the extreme rigour of the climate. He consumes such a large amount of the heat-producing elements, being in the habit of eating—when he can get it—eight or ten pounds of whale blubber per diem, that a difference of twenty or thirty degrees in the temperature of the atmosphere is of little importance to him. On the other hand, you find that in warmer climates, men not only require a less amount of heat-producing materials, but if they take them in too large proportions into their system, they are thrown by them into bilious diseases; while, if they attempt to subsist upon them in the hottest weather, they soon cease to exist.

I shall now refer to the nitrogenous elements found in food. These are the real elements of nutrition; they are the producers of flesh, and must be kept perfectly distinct in our minds from those substances which produce only fat. Among the producers of flesh we have vegetable fibrine, the gluten of wheat, albumen, and vegetable caseine. If you take the turnip and press it, you will have the fibrine or gluten in the pressed mass, while the juice will contain the albumen and caseine. If you boil this juice, you will have a coagulum of albumen precipitated, exactly as if you had used the albumen or white of an egg. If you separate it by filtration, and then add an acid to the filtered liquid, you will have another precipitate, similar to that which goes down from milk, on the addition of rennet or an acid, and similar in all its relations to the curd of milk. This, which goes down last, is called caseine, because it is precisely similar to the curd of cheese. That which goes down by boiling, is called vegetable albumen, because it resembles the albumen of an egg; and that which remains insoluble in the pressed mass, is called vegetable fibrine or gluten. These three substances differ in the following manner: the fibrine or gluten is insoluble in water; the albumen is soluble in water, but is coagulated and precipitated on boiling; and the caseine, or cheesy principle, is soluble in water, not precipitable by boiling, but separable on the addition of an acid, such as rennet or vinegar. The most important fact has yet to be mentioned, namely, that these bodies are almost identical in composition, and that they are also of the same composition as the flesh of animals in general. Vegetables, then, clearly produce the staple of flesh, and animals merely alter its mechanical structure and condition.

Now I beg you to observe the immense importance of these bodies. Vegetable albumen is similar to, if not identical with, animal albumen—the white of an egg. Now see what a very little thing will change the white and the yolk of an egg into totally different substances. You have only to take the egg, with its principle of vitality, and to expose it to a certain temperature for about three weeks, and you obtain bones, sinews, muscles, claws, beak, eyes, feathers, nerves, lungs, liver, intestines, and the various other parts of the animal economy. All these come from these apparently simple substances, merely through the action of heat and the principle of vitality. In like manner, when vegetable fibrine and caseine are introduced into the stomach of an animal, and are operated upon by the vital functions, they are dissolved and distributed through the various parts to form the different bodily organs required by the animal. I will here refer to some analyses, made by various distinguished chemists, of the gluten, caseine, and albumen obtained from vegetables and animals:—

	Carbon.	Hydrogen.	Oxygen, &c.	Nitrogen.	
Vegetable fibrine or gluten,* ..	53·27	7·17	23·62	15·94	Dumas & Cahours.
" Albumen,* ..	53·74	7·11	23·49	15·66	" "
" Caseine,* ..	54·14	7·16	23·03	15·67	Scherer.
Animal fibrine,*	53·83	7·02	23·57	15·58	Jones.
" Albumen, ..	53·37	7.10	23.76	15·77	Dumas & Cahours.
" Caseine, ..	53·50	7·05	23·68	15·77	" "
Ox flesh, ...	54·18	7.93	22·18	15·71	Playfair.
Ox blood, ...	54·35	7·50	22·39	15·76	" "

There is the greatest similarity between these substances, whether obtained from vegetables or from animals. Now it is impossible to imagine that these materials, so nearly agreeing in their composition with flesh, can be changed at all in their nature when taken into the system; that they can when there receive any addition either of carbon or of nitrogen. There can be no doubt whatever that vegetables produce the flesh of animals; that the flesh of all animals has been prepared and made originally by vegetables; in other words, that animals dissolve already-prepared matters, and, under the action of vitality, give them different mechanical forms, and put them on the muscles of the body. We

* These bodies contain about 1·5 per cent. of sulphur, and ·4 of phosphorus, the amounts of which are included in the oxygen column.

have no reason to believe that the stomach of the animal acts upon these matters in any other way than by solution, the vital force afterwards putting each particle into its proper place in the system. These nitrogenous matters are the real sources of nutrition, the producers of flesh; their substances—the fibrine, the albumen, and the caseine—are those from which we derive our muscles. If an animal were fed upon the elements of respiration alone—upon fat, oil, gum, starch, or sugar—it would be perfectly impossible for it to grow, to work, or to live. If a labouring man were fed upon non-nitrogenous food, he would soon die: no human being could exist on such substances. Arrow-root, starch, and all similar materials, of themselves are insufficient to sustain life; they may do very well to produce animal heat, but it would be perfectly impossible to live on them alone; they must be united with other materials, containing nitrogen, which alone can repair the daily waste of the muscles. Every motion which an animal makes with any muscle causes a proportionate wasting of that muscle. At the time when the motion takes place, the oxygen attacks the muscle and dissolves a portion of it, equivalent to the amount of motion and force produced. This is a method of heating independent of the use of non-nitrogenous or fatty and starchy foods. You know that there are animals which live entirely on flesh. These require a large amount of exercise; the muscles of the body not being consumed, they are obliged to keep in motion. Any of you who have seen the carnivorous animals at the Zoological Gardens in their dens, must have observed that they are almost incessantly in motion; and this motion arises from the fact that they consume a large quantity of nitrogen, which can only be got rid of by means of exercise. In all cases of motion, there is a consumption of the muscles of the body, and the elements of nutrition are required to replace what has been lost. The life of an American Indian hunter is peculiarly suited to the food which he consumes. Such men will sometimes go for days together without food, during which time they will of course consume a large quantity of the muscles of their body; but when they have caught their prey they devour large portions of it, and in a very little while, what was the flesh of a buffalo, or some other wild animal, has become that of a man. Thus the pursuit of the hunter is well adapted to his food, and his food is equally adapted to his pursuit. I recollect a case, related by Sir William Alexander, which tends to illustrate this point. When he was travelling in Caffreland, there one day came into the kraal a man who was almost starved, and whose body was so emaciated with want that it seemed as though he could hardly survive another day. Sir William had often heard, that, in that part of the world, men who had been a long time without food would eat a sheep, if it were given to them, without the slightest difficulty; and he was told that if he gave this man a sheep he would get well directly, although he seemed so near his end. After some hesitation, Sir William gave him one of the Cape sheep, which, though not quite so large as our Leicesters, weighed, perhaps, from thirty to forty pounds. The man commenced eating the animal, and did not leave off until he had consumed about three-fourths of it. On the morning of the succeeding day, Sir William found him strong and well; so quickly had the muscular materials of the sheep been laid upon the muscles of the man. Many similar instances might be given of this apparently marvellous effect—apparently marvellous, I say, for it is not so when considered in the proper light. In cases of this kind, the animal economy has nothing to do but to dissolve the food which has already been prepared for it, and to place it in its proper position on the muscles, which are equally prepared to receive it. I may here remark that, of all vegetables, beans, peas, and lentils contain the greatest amount of flesh-producing principles.

Having thus mentioned these two kinds of food—nitrogenous and non-nitrogenous—I desire now to point out what we may learn by way of deduction from this, namely, that both rest and warmth are necessary for the animal's due increase and proper development. First, let me notice warmth, which is so important that I need not apologise for introducing it a second time. As animals must consume, in their bodies, a certain amount of the elements of respiration in order to produce heat, and as they can only lay up fat in proportion to what remains after the necessary production of animal heat, it is evident that they should always be so sheltered as to be enabled to use the elements of respiration which are found in their food. It is also clear that if you take a pound of starch, or oil, or gum, or sugar, and burn it for the production of heat, it will produce far less heat than a pound of coal will produce for the same purpose. Therefore, the time will come, I think, when coal will assist the fattening of bullocks in the winter: when, either by steam or by stoves, the animal will be artificially warmed, and left in such a state as to require far less food than he otherwise would for the production of internal heat. I am decidedly of opinion, that any gentleman who is engaged in the fattening of animals, would find it cheaper to purchase coals than to consume an equivalent amount of the materials I have mentioned. Again, rest is necessary for the animal. As every motion produces a corresponding destruction of the muscles which make it, it is quite clear that the more animals move about the more of the elements of nutrition will they require to supply what has been wasted. Everybody knows the difference between a long-legged Irish pig, which gallops about like a race-horse, and one of Mr. Fisher Hobbs's little pigs, whose diminutive legs would scarcely suffice to carry it through this room. The difference which exists as regards fattening properties, of course arises from the different quantity of exercise taken by the two classes of animals. If you want your animals to be well fatted and fleshed, you ought not to allow them much motion; you ought to keep them for the most part quiet, and to let them have no more exercise than is absolutely requisite for health. This is a case in which men of practical experience cannot but agree with me. I should be very sorry indeed if you allowed your animals no motion whatever; because I think that, considering the long period it takes to fatten them, some degree of it is indispensable to health; but depend upon it, in many cases—as, for instance, that of young calves destined for the butcher—the less motion there is the better.

There is another point of considerable importance. We know that animals which are often asleep, gain more flesh than others which are more wakeful. If you darken a place where animals are kept, you will find the animals much more disposed to be drowsy, and consequently exhibiting a much greater tendency to fatten, than will be the case if they are exposed to the light.

I shall now proceed to consider the necessity of adopting a distinct treatment for fattening and for growing stock. The proper modes of treatment to be pursued are quite different, and those who make no distinction, will in the end find out their mistake; similarity of treatment cannot but fail in the result. The young stock which you intend to grow must have very different treatment from the stock you intend to fatten for the market. You want the former to have a good constitution, and to increase their muscles and general size, and these objects can only be secured by means of a considerable amount of exercise. Every one knows that the arm with which the blacksmith strikes the most becomes strong by constant exercise. In like manner, young stock should have frequent exercise in the open air, and take as much food as they can eat of the proper kind, in order that they may fulfil the purpose for which they were designed. There is one great mistake committed with regard to young animals. It is supposed that before they have been weaned they can do with skimmed milk; in fact, that the materials which nature has provided for them can be diminished in value without their experiencing any corresponding injury. There can be no greater error than this. The milk itself is well adapted for the purposes of nutrition. It contains caseine for the production of flesh, phosphate of lime for the production of bones, and sugar of milk and fatty matter for the production of heat; thus giving everything that good food can yield. But if you take away the butter, and give the animal skimmed milk, you diminish that which nature has provided for the purpose of maintaining animal heat, and the animal may get cold, and be fevered. If, in fact, you diminish what nature has provided, you are sure to sustain corresponding loss. If you want to use the cream for butter, you can add an infusion of linseed to the skimmed milk; and when you are beginning to wean the animal, you can by means of an infusion of boiled beans, which contain caseine, and of linseed, which contains gum, with a little treacle or sugar, make a powerful milk; for in these substances you have all that was to be found in the original milk. Great care should be taken in the rearing of young stock to give them the elements of nutrition. You must not confine them to oily and starchy compounds ; for these will not serve the purpose. Even in the case of the human subject, parents often fall into a very great error by feeding their children upon arrow-root alone, or upon other similar substances. They suppose that arrow-root contains some flesh-producing principle, when in point of fact it contains nothing of the kind, but is merely starch, and consists of carbon, oxygen, and hydrogen. It may be very well for persons who are unwell, and whose stomachs are in a delicate state, to take the lightest kind of food ; but for children, or those who are growing, it is the worst kind of nutriment that can be given. On the other hand, those kinds of food which contain the greatest proportion of nitrogen are the most useful for nutrition. There is a food recently introduced by Mr. Bullock, of Conduit Street, which consists of the flour of wheat kneaded with water till nearly all the starch has been got from it. This contains six times the amount of nutriment that is contained in ordinary flour, and it is one of the best kinds of food that has ever been devised. I repeat that young and growing stock ought to take exercise ; it is absolutely necessary for them, in order that they may have a good constitution, and that the muscles, well developed by exercise in youth, may have proper capacity for increase in age.

I shall next refer to the cooking of food, and to the difference between barley and malt. On this subject I may observe, that there is a great deal of misunderstanding as to what cooking can effect. If nutritive and useful materials exist in a certain kind of food, cooking can only be useful by aiding their solubility. It will make them more soluble, and on that account a less amount of food probably will pass through the system undigested. I do not suppose that if we were to steam sawdust for any length of time, we should convert it into a good food for animals. Those parts of the substance which are indissoluble, and which consist of woody matter, still remain ; but the other parts, such as starch, or gum, or oil, or fat, are made soluble in water, and consequently will be more easily assimilated. The great point to be kept in view, is the making the food more soluble, so that it will be more readily acted upon in the animal. But there are two sides to this question; and it is very important that such things should not be carried too far. The functions of digestion are, I need scarcely say, very important; nor are they so simple as some are apt to suppose. There are more processes than one going on; and there are many things to be considered in relation to them. If the requisite amount of saliva be not swallowed, this may cause a great defect in an important element of health; and if animals swallow their food too quickly, probably they will not have sufficient saliva for digestion. It is necessary to avoid, I say, going to extremes in these matters: it is quite possible to prepare food so that it will be too easily swallowed. On this subject I would suggest to gentlemen who are engaged in farming, to observe whether my remarks are not borne out by their own experience.

On the subject of the difference between barley and malt, there have been a very great number of discussions. We have had the government giving results, which are corroborated, to a certain extent, by the experiments of Mr. Lawes; but, notwithstanding this, I consider the question as yet by no means perfectly settled: I think it necessary that some additional experiments should be made. As far as I understand the experiments of Mr. Lawes, the plan on which he proceeded was that of giving to animals continuously a certain quantity of malt; whereas in my judgment malt should be given, not continuously or exclusively, but as an occasional stimulant, and along with other food. There is a decided loss of vegetable matter in the process of malting or germinating. It must never be forgotten that a quarter of barley does in fact contain more nutritive matter than an equivalent quantity of barley converted into malt; and it is possible that by merely steeping barley, you would obtain all the good that you would secure by drying and making malt. I make these remarks, because I think it very desirable that some other experiments should be performed, for the purpose of clearing up the question, and deciding whether malt used in smaller quantities than by Mr. Lawes and Dr. Thompson, may not be a useful adjunct in the feeding of animals, and cause them to eat and fatten more than they otherwise would.

Another point which I think it necessary to mention is the use of salt. The effect of salt, as taken into the system, is to enable the animal to form bile. Bile is a compound of a sort of carbonaceous resinous matter and soda. Soda, as you all know, is formed from common salt. Without the presence of common salt in food, no bile can be formed; its presence is essential to the healthy action of the animal frame. But mind, any means which produces an excess of bile merely robs the animal of a portion of its food, and prevents the formation of a quantity of fat; because the bile is formed from fat, oil, gum, sugar, and so on, and really represents and embodies the carbonaceous materials destined for immediate consumption. The more bile you produce the less fat you produce; and the more salt you give to animals the more bile you allow them to form. In these remarks I allude especially to fattening, not to growing stock. To the latter, salt may often be an advantage; but though fattening animals may like salt, I think it injudicious to give them the free use of it. It is quite evident that, in summer especially, animals are very fond of salt; but if you want them to grow fat with the least expenditure of food, I think you ought to give them salt only in very small quantities. And then you are also to remember that all vegetables contain salt. A bullock will eat daily in its food five ounces of salt, which is contained in the ordinary saline materials of the food itself. If I were inclined to give animals salt at all, I think I should do so by the indirect mode of throwing it upon the land, and leaving the animals to take it up in their food.

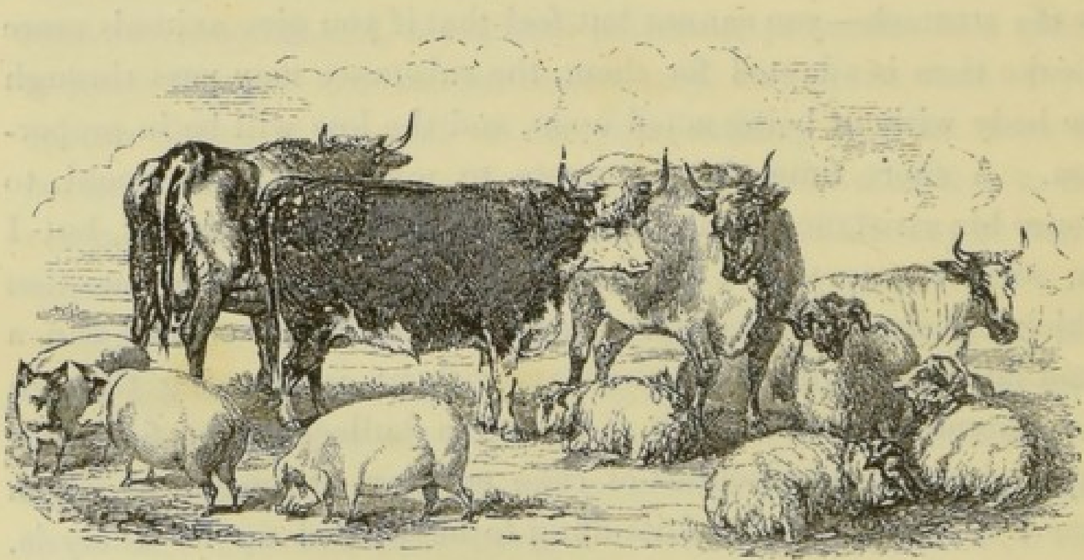
Another point which I wish to mention, is the selection of stock. Of course I do not mean to dictate to practical men how they should choose their animals; but I may, perhaps, be permitted to remark, that the animals which are likely to prove the best for the market are those which have the smallest bones, liver, lungs, and intestines. This leads us to the consideration of the constitution and fattening properties of different animals. We all know that when animals are fattening, and have gone on fattening for some time, they require a much smaller quantity of food than they did at the commencement of the process. Of course the more oxygen is taken into the system by the lungs, the greater is the consumption of the elements of respiration, and the less the production of fat. Animals with small lungs, livers, and intestines, will consume the least amount of food, and have the greatest tendency to fatten. They will consume less of the ordinary kinds of food; they will also produce less bile, and consequently a greater amount of fat with a less consumption of food. Now, what is the case with regard to the horse? It is entirely different from that of which I have just been speaking. In the case of the horse, you want the largest lungs; because what is chiefly required is wind. You do not want horses to fatten, but you want them to have large lungs, so as to be able to keep up their pace; and therefore in the treatment of horses, you should pursue a totally different system from that which you adopt with regard to fattening stock. And here I would observe, that stock, fattened in the manner I have described, are evidently more delicate and more liable to disease than animals which have from infancy been exposed to the ordinary varying influence of climate. Therefore, it is important to consider whether it be not possible that we carry our breeding too far, and sustain loss from having animals which are too delicate.

Another point to which I would advert is ventilation, the want of which is, I believe, a fertile source of loss to many gentlemen who are engaged in farming. I have, in various parts of the country, been into stables and sheds, which are not only unfit for any human being, but for any animal whatever to live in, and where animals have been obliged to breathe, over and over again, materials absolutely destructive to life I have thought that a few experiments on this subject would more clearly show the necessity for attending closely to the matter than anything which I could say, and these experiments I will now proceed to exhibit, in the hope that they will answer the design. The noxious gas given out of the lungs, partakes of the character of the smoke which escapes from chimneys. We all know that if persons shut themselves up in a room, close the door, and then burn pans of charcoal, they must speedily die; they will, in fact, be killed by the fumes of charcoal which come out of the pans. In like manner, all animals may be killed by the fumes given out from the lungs; and when stables and other places are not sufficiently ventilated, this effect, gradually at least, often takes place. The same noxious gas arises from all burning bodies which contain carbon. It is one of the properties of this gas to form a white precipitate with lime or baryta water. On holding a common ale-glass over the flame of a candle, or burning paper, closing the mouth of it with the hand, then pouring a small quantity of lime-water into the glass, and shaking it, a white precipitate will be formed. [Experiment performed.] To illustrate more clearly and easily the properties of this gas, called by chemists carbonic acid gas, I will procure some from common chalk, which is carbonate of lime. On adding a little common muriatic acid and water to the chalk in this jar, the stronger acid will liberate a large quantity of this gas, and we can then examine its properties. [The gas prepared.] This gas is much heavier than the air, which it has no doubt completely driven out of the glass: this we shall discover by inserting a lighted taper, which will be immediately extinguished. On pouring a little of this gas into the lime-water in this glass, you perceive the same white precipitate as from the gas of burning bodies; and, though you cannot see the gas because of its transparency, yet if I pour from this apparently empty jar the contained gas over the flame of a candle, it will be put out. Whatever extinguishes flame would also extinguish animal life: the one effect is just as certain as the other. It is the gas thus produced which is called the after-gas, or choke-damp, of the miner, and which destroys the lives of so many persons in pits whenever an explosion takes place—the after-gas destroying, in fact, far more lives than the explosion itself—those who were not killed by the one being destroyed by the other. I will now show you that the gas of my lungs will give precisely the same precipitate as this noxious gas from other sources. It may be as well to mention here, that the quantity of this poisonous carbonic acid given out daily by man is 27 cubic feet—by the cow 137 cubic feet; these numbers also representing the amount of oxygen united with charcoal in the system to produce the necessary animal heat. Now, I would observe, that there is a double deterioration going on where an insufficient quantity of air is breathed by a number of animals: first, the oxygen, without whose presence we cannot live, is absorbed; secondly, it is replaced by carbonic acid, which is a deadly poison. To what an extent, then, may the air be deteriorated by inattention to this subject! I would here refer to what the Almighty has done in nature, as it tends to show the importance of the whole question. God has so diluted this substance, that 10,000 feet of common air contain only 2 feet of carbonic acid. It has been ascertained that five per cent. of it in the air acts as a poison to animals. Therefore, in order to know how much air would be vitiated in one day by a horse, you have only to multiply 190 cubic feet by 20, and the product will be 3,800 cubic feet of air, which would be rendered perfectly poisonous by one horse in twenty-four hours, and half of that amount, 1,900 cubic feet, in the course of twelve hours. It is, therefore, quite easy to understand how poisonous may be the air of stables. Air, with four per cent., three per cent., two per cent., or even one per cent. of carbonic acid, must have poisonous properties in a greater or lesser degree. In relation to economy, and to the state of your balance-sheets at the end of the year, nothing can be more important than the subject of ventilation. Without attention to this, you may give animals the best kinds of food, and all may be turned to poison: you will be only throwing away your money.

Now, as I said before, all that it is in my power to do is to bring before you principles, leaving you to test them yourselves by practice. There are so many important points embraced in the subject, that it would have been impossible for me to notice them all; but sufficient have, I trust, been introduced to elicit inquiry and discussion.

There is one other point which I must notice before I conclude, namely, the necessity of mixing different kinds of food together, with a view to the assisting proper and healthy digestion. You should take care to have a proper mixture of nitrogenous and non-nitrogenous food. The carnivorous animals, as you well know, live upon flesh alone; and between them and herbivorous animals there is a very great difference, as regards the changes to be made in food. The proper mixture can, in fact, only be determined by experience, but great care should be taken not to give too much food, whether of one kind or of another. It is quite possible to injure an animal by the amount of one particular kind of food which you give to it. It is a question to what extent even oilcake should be used in fattening animals. I believe that, in a great number of cases, it is given to too large an extent. Persons sometimes give animals large quantities of this food under the supposition that, if it do not benefit the animal itself, yet by passing through it it will secure benefit in the shape of manure. All I will say on that subject is, that a ton of guano is equal, in manuring powers, to two tons and a half of oilcake; and that, therefore, unless the latter benefit the farmer by being converted into beef or mutton, it will be a most expensive medium of manuring. When you know that there is such a thing as food passing through the animal system without being digested—when you know that starch granules may pass through the system without being acted upon by the stomach—you cannot but feel that if you give animals more oilcake than is adapted for them, the substance may pass through the body without being acted upon, and the loss will be in proportion. A short time since, I wrote to my friend Mr. Mechi to secure his assistance in illustrating my lecture this evening, but I am sorry to say that I have been disappointed. The question which I wished to have solved is this: How much oilcake can a good fattening bullock eat per day, without any passing through the system unacted upon? I wished a bullock to be fed three days, with say three pounds of cake per day, at the end of which time I wished a sample of its dung to be bottled up for analysis. The next three days the animal should have six pounds per day, and then nine pounds, and so on. The various samples of dung should then be analysed—the quantity of oil and the amount of nitrogen carefully determined; and then we should have the means of knowing how much went through the animal untouched and unacted upon.

I will not trespass further on your attention. I will only say, in conclusion, that I think, as agriculturists, you ought to cherish science. True science never puts itself out of its place; and I think true practice should never do so either. What we want is a union of the two. It would be better if practice and science were united in the same person; but so long as that is not the case, and so long as the rising generation are too young to apply what they are learning, we must look to a union of scientific men with practical men. The really scientific man who knows the requirements of farming, will never for a moment conceive that he can supersede the practical experience of ages by any theories of his own; and, on the other hand, the practical man should not be too ready to condemn the scientific man, because he is unable to explain every circumstance and every fact in nature.



ON PERUVIAN GUANO:

ITS HISTORY, COMPOSITION, FERTILISING QUALITIES, AND MODE OF APPLICATION TO THE SOIL.

In reviewing the history and condition of agriculture for the last twenty years, it is impossible to avoid being struck by the remarkable progress, scientific and practical, which the latter half of that period has witnessed.

The genius of our mechanics has been shown by the invention of a wonderful variety of new and interesting instruments adapted for an improved culture of the soil. The steam engine also, hitherto almost exclusively used by the manufacturer, now lends its powerful aid to the farmer. The art of the drainer has brought into successful cultivation thousands of acres of wet and almost worthless soil; and a vast breadth of land, previously only partially drained, has been permanently and effectually ameliorated.

But perhaps the most remarkable feature of the whole is the introduction of the so-called "Artificial Manures," and the vast advantage derived by agriculture therefrom.

Previous to 1840, with the exception of local manufacturing refuse, the only artificial manures were bones, salt, and gypsum.

The introduction of bones, many years back, was of great importance to the farmer, and enabled him to grow, with comparative ease, that mainstay of the four course shift—the turnip.

To the impoverished soils of Cheshire, and other cheese exporting counties, bones were also an immense boon, and were duly appreciated.

The publication of the first edition of "Liebig's Agricultural Chemistry," in 1840, forms an important era in agriculture. Since that period, the chemist has more generally directed his experiments to the investigation of the true principles of fertility, the merchant has sought for foreign sources of valuable manure, and the farmer has reaped the benefits of the labours of them both.

That an increase of solubility in bones and other phosphates would be attended by an increased productive power in the crop, was the idea of Liebig. This great chemist, in 1840, recommended, in lieu of bones, the use of the substance long well known to chemists as the acid or superphosphate of lime, which is producible from bones and other phosphates by the action of sulphuric acid. Practice has since shown the great advantage of Liebig's suggestion.

The introduction of the dung of birds and other animals, under the name of "GUANO;" and the discovery, in Suffolk and other counties, of immense quantities of fossil bones, and other animal remains, known as "COPROLITES," have followed quickly upon each other; and there can be no doubt that, by their means, an entire revolution will be made in the practice of agriculture.

The concentrated character of most of the genuine artificial manures, particularly adapts them for use in the mountainous and hilly districts of our country, where the carriage of ordinary manure is both difficult and expensive. One wagon may now easily carry enough manure for fifteen or twenty acres of turnips. Formerly fifteen or twenty loads were required for a single acre.

Of all the artificial manures, Peruvian guano is perhaps not only the most concentrated, but is, from its composition, adapted to the greatest variety of crops. The chief mineral constituents of plants—lime, magnesia, potash, soda, chlorine, sulphuric acid, and phosphoric acid (the latter the most important), are found in guano. Nitrogen, the most valuable constituent of manures, is found in Peruvian guano in great abundance, and in a condition adapted for vegetation.

The use of this manure in Peru is of very ancient date; and for its preservation, and that of the birds by which it was deposited, the most stringest precautions were made use of by the native Incas and their Spanish successors. At one period the punishment of death was inflicted upon any one disturbing the birds in the breeding season.

The Chincha islands, which contain the great guano deposits, are situated in the Pacific Ocean, off the coast of Peru, at the distance of about twelve miles.

They lie between lat. 13 deg. and 14 deg. S.; a zone within which no rain falls, where the air is dry, and the sun shines with vehement power. The waters of the surrounding ocean contain innumerable shoals of fish; and myriads of birds, after daily satisfying their voracious appetites upon the finny tenants of the deep, have for ages made the islands their nightly abode, and the receptacle of their fæcal offerings. From the arid nature of the climate, the excess of humidity has speedily evaporated from their ordure, decomposition has been arrested, and by gradual accumulation from time immemorial, these extraordinary deposits have attained the depth, in many parts, of one hundred feet.

The guano, as found on the islands, is subject to slight variations in composition. Towards the S.W., the deposits are more exposed to the action of the spray of the sea, brought by the prevailing winds. Some of these guanos have lost by this means a large amount of ammonia, and are not brought to this country; in others, the deterioration is trifling, and many are simply discoloured, without having suffered any other change, and are equal in value to paler samples.*

That the excrementitious matter of birds, fed upon an unlimited supply of animal food, would of itself have powerful fertilising properties, might almost have been taken for granted, without either calling for the opinion of the chemist, or the experimental proofs of the farmer. But both chemist and farmer alike bear testimony to the high position assumed by guano in the catalogue of manures: the former, by comparing its composition with that of other known fertilising bodies; the latter, by actual trial in the field.

It has long been a growing opinion with chemists, that ammo-

* Messrs. Ant. Gibbs and Sons, as agents in this country of the Peruvian Government, are the sole channel through which the Peruvian guano finds its way into commerce.

nia and phosphate of lime are the two most important and valuable elements of plants, and, consequently, of any manure which is to aid in the development of vegetable life. This opinion has been founded, in the first place, upon numerous analyses of various manures; and, secondly, upon practical experiment.

It has been proved, for example, that, in two samples of farm-yard dung, the one which gives the best crop in practice, contains on analysis the largest amount of ammonia and bone earth. It is a well known fact, that the seeds of a vegetable contain more nitrogen (ammonia) and phosphate of lime than any other portion of the plant; and it is also well known that the dung of animals fed upon seeds is more valuable than that of others fed only upon hay, straw, or roots. Hence the practice of feeding animals upon oilcake (crushed linseed), to obtain a better quality of dung. That ammonia and bone dust are the most valuable of manuring principles, may also be inferred from the fact, that the artificial manures most used by the farmer are those which contain the greatest quantities of these elements, and that these manures are precisely those which fetch the highest price in the market.

A comparison, therefore, of the composition of various excrements of animals, and of farm-yard dung, with that of an average sample of guano, will afford a very fair means of ascertaining their relative fertilising powers.

The following table contains analyses of various manures, made by Boussingault, and other well-known chemists, and also the analysis of an ordinary sample of Peruvian Guano.

ANALYSES OF FARM-YARD DUNG, &c.

	Farm-yard Dung.	Horse Dung.	Cow Dung.	Pig Dung.	Mixed liquid and solid excrement of man.*	Peruvian Guano.*
Moisture	79.30	76.17	86.44	82.00	94.24	18.35
Organic matter ...	14.03	19.70	11.20	14.29	4.72	51.25
Inorganic matter .	6.67	4.13	2.36	3.71	1.04	30.40
	100.00	100.00	100.00	100.00	100.00	100.00
Nitrogen (equal to)	0.41	0.65	0.36	0.61	0.94	13.88
Ammonia............	0 49	0.78	0.43	0.74	1.14	16.85

* These analyses were made in the laboratories of the College.

Boussingault, Payen, and many others of our first practical Agricultural Chemists, have come to the conclusion that the value of different manures varies nearly in proportion to the amount of nitrogen they contain. There may be cases to which this rule is not exactly applicable; but in many natural manures, an increase of nitrogen is accompanied by an increase in the phosphate of lime, and every other valuable manuring element. In the above table, for instance, the 13.88 of nitrogen in the guano, is accompanied by 30.40 parts of inorganic matter, of which 23.60 parts (or more than two-thirds), is phosphate of lime.

If we take the per centage of nitrogen, then, as a correct indication of manuring value, we shall find that one ton of ordinary Peruvian guano, is equal to

33½ tons of farm-yard dung.
21 tons of horse dung.
38½ tons of cow dung.
22½ tons of pig dung, and
14½ tons of mixed human excrements.

Let those who farm in hilly countries, and other places where carriage is expensive, ponder well the above facts.

Though a good farmer will produce as much manure as he conveniently can, yet even farm-yard dung may be bought *too dear;* and it is certain that on numbers of farms the cartage of dung is so expensive an item of management, that the introduction of guano for those parts at the greatest distance from the homestead, would be productive of the same fertility, at a considerable saving of expense.

A question now arises whether the fertilising properties of guano will be expended in the first year of its application, or whether its operations will be discernible in after periods. If we examine the chemical constitution of guano, we shall find it to occupy the medium position between those manures which, being altogether soluble, are somewhat transient in their effects, and that other class, which, like bones, are only slowly decomposed in the land, and yield their manuring principles with a certain degree of difficulty. Guano, in fact, possesses every advantage of both. From analyses which have been made, it is found that about one half of the fertilising properties of guano are soluble in water, and therefore adapted for the instant nourishment of plants. The other half continues long in the soil, eliminating nourishment for vegetables by slow decomposition. The soluble phosphoric acid, which it has been found necessary to produce artificially from bones by sulphuric acid, exists naturally in guano. If a guano contain in the whole say twelve per cent. of phosphoric acid, and seventeen per cent. of ammonia, we shall find that water will dissolve about six per cent. of phosphoric acid, equal to about thirteen per cent. of phosphate of lime in a soluble state,—and at least eight per cent. of the ammonia. Guano is thus adapted, by its insoluble matter, for the lighter soils, where infiltration might too rapidly carry away the soluble matter; and by its soluble constituents it is fitted for heavier lands, where decomposition being slower, a supply of soluble manure is required at once.

The fact of so considerable a portion of soluble phosphates existing in guano is of great importance, as we have in a natural form that which we are obliged to produce artificially in other manures, by the action of acids upon bones and other insoluble phosphates.

In fact, good guano partakes of the nature of superphosphate of lime, as it contains both soluble and insoluble phosphates. These together generally amount to the average quantity found in commercial superphosphate of lime.

At the present price of Peruvian guano, it is more than questionable whether the ordinary plan of increasing the available manure on a farm by the importation of oilcake and the feeding of stock is at all economical. If the oilcake owes its fertilising properties to the nitrogen and phosphate of lime it contains, it is certain, from the analyses of various chemists, that Peruvian guano is a much cheaper source of these substances. In a lecture lately delivered by the author before the farmers of Dorchester, this subject was alluded to as follows:—

"It may here be necessary to notice another question of great importance, viz.:—Is the use of artificial food (such as oilcake) for stock, the *cheapest* mode of introducing bone earth and ammonia into the land? Many farmers are content if their fat stock produce as much money as will pay for the oilcake used, together with the price of the lean animals bought; thus sinking altogether the turnips, mangold, and hay, likewise consumed by the stock. It appears to be clear that, unless the oilcake affords a profit by the beef or mutton, a more expensive system of *manuring* could not well be pursued. The following table, comparing the manuring values of oil and rape cake with guano, may be of some service in determining the practice of the intelligent farmer:—

Table of the Manuring Values of Oilcake and Rapecake compared with Peruvian Guano, from Analyses made in the Laboratory of the Agricultural and Chemical College, Kennington.

	Oilcake from Liverpool.	Oilcake from London.	Oilcake from Marseilles.	Rapecake.	Peruvian Guano.
	lbs.	lbs.	lbs.	lbs.	lbs.
Moisture	268.8	300.7	274.4	195.8	268.8
Organic Matter	1739.6	1699.3	1718.3	1654.2	892.2
Nitrogen	109.1	118.5	118.2	115 4	295.0
Ammonia	130.6	143.8	143.4	140 0	358 4
Inorganic Matter	122.5	121.5	129.1	274.6	784 0
Containing—					
Phosphoric Acid	47.1	30.9	39.4	43.7	224.0
Potash	29.1	19.1	23.7	27.1	67.2
	2240.0	2240.0	2240.0	2240.0	2240.0

"From the foregoing Table, it appears that one ton, or 2,240 lbs. of Peruvian guano, containing 16 per cent. of ammonia, would introduce into the farm six times the phosphate of lime, two-and-a-quarter times the potash, and more than two-and-a-half times the ammonia, that would be furnished by one ton of the best oil or rape cake. To pass oilcake through the bodies of animals, without some attendant benefit, is both expensive and wasteful; and unless you can find your profit in the increase of the beef and mutton, it is an improper expenditure of money."

These observations are amply supported by the opinion of the members of one of the most intelligent Farmers' Clubs in England. The Botley Farmers' Club have *unanimously* resolved, "That where there is not sufficient dung for the wheat crop, it is more profitable to apply concentrated manures than to purchase dung; and that an equal amount of money expended in the purchase of concentrated manures will raise more wheat than the same amount expended in the purchase of oilcake or corn, and converted into dung by feeding cattle." And the Rev. L. Vernon Harcourt, speaking of this decision of the Club, says, "all my experiments tend to corroborate the view taken by the Botley Club on this subject."

Leaving these facts and opinions to the consideration of those farmers who seek to combine good farming with economy of manuring, we shall now offer some suggestions as to the best mode, and the proper time, of applying guano to different varieties of crops.

ON THE MODE OF APPLYING GUANO TO THE SOIL.

It requires but a short consideration of this subject to perceive, that before any useful practical rules can be obtained for the application of guano, we must carefully compare the properties of the soil with those of the manure to be applied. Reference must also be made to the different conditions of the atmosphere at different seasons, particularly as respects moisture, dew or rain. The nature of the crop will also materially influence the quantity of guano to be used, and the time of its application.

Practical men have long been aware of the great difference existing in soils as regards their retentive power for manure. On certain lands, the result of the application of a given quantity of farm-yard dung may be seen for a number of years. On others, the effect of the same quantity ceases to be visible in a very much shorter period. The former class includes the loams, clays, and in general the heavier descriptions of land; the latter comprises the sands, gravels, chalks, and other lighter qualities, not inaptly termed by the farmer "*hungry soils.*"

These varieties of soil differ both in chemical composition and mechanical properties. The heavier in general contain more alumina and oxide of iron than the lighter ones. They are also less porous, even when drained; their particles are finer, and their absorptive power is greater. The want of great porosity prevents the too rapid action of the atmosphere on the manures they may contain, and their absorptive power enables them to retain, to a considerable extent, the liquid and volatile elements of the manure, and at the same time to obtain a certain quantity at the expense of the atmosphere.

The case is, however, different with gravels, sands, and the lighter soils; upon which, in consequence of their greater porosity, the atmosphere acts freely, and to a considerable depth.

When manure is applied to them it is rapidly decomposed, and unless there be a growing crop ready to absorb the fertilising particles as they become soluble, they will be washed away; or, if they become volatile, will, to some extent, be absorbed by the atmosphere. These soils, therefore, require different treatment. We may apply to heavier lands a strong dressing of manure at once, and little loss will ensue, for some time at least, from any other source than the action of the growing crops. On the lighter soils, we must use, even of farm-yard dung, a less amount at a time, but it must be applied more frequently. We thus see that light lands have the advantage of more rapidly decomposing the dung, and consequently of preparing it more quickly for the use of the plant. For this reason, among others, light soils are preferred by the market gardeners, who, by their repeated manurings and repeated croppings, practically show how these soils may be most efficiently managed.

It may not be uninteresting here to introduce some experiments made at Kennington, with the view of obtaining a further insight into the properties of guano, and the action of light soils upon it.

EXPERIMENT I.

A small quantity of Peruvian guano was placed in a saucer, and the whole covered with a bell glass containing a slip of red litmus paper, moistened with distilled water. In the course of an hour or two the slip became distinctly blue.* This proves the escape of a small amount of ammonia from the guano simply by exposure to air.

EXPERIMENT II.

A quantity of guano was mixed with four or five times its weight of ordinary light garden mould, and slightly moistened. It was covered, as before, with a bell glass. The strip of litmus paper became blue in two or three hours.

This experiment proves that a small amount of light soil mixed with guano will not prevent the escape of ammonia.

EXPERIMENT III.

Two grains of guano were intimately mixed with two thousand grains of light soil, and covered with a bell glass as before. The mixture was slightly damp, but not wet. After the lapse of twenty-four hours, the litmus was very faintly tinged with blue. A little pure distilled water was now added to the mixture. After the lapse of another day, the tinge became much deeper.

From this it is apparent that even a large excess of soil will not prevent the escape of a certain amount of ammonia. From another experiment, it was evident that even the soil itself exhaled a minute trace of ammonia.

EXPERIMENTS IV. V. AND VI.

These were made upon a piece of meadow attached to the College at Kennington. Two portions of land about two months before had been dressed with guano, at the rate of two-and-a-half cwt. and five cwt. per acre, respectively. Another portion received no dressing at all. A bell glass, with moistened red litmus, was deposited carefully, mouth downwards, upon each of the three

* Red litmus paper is rendered blue by the action of ammonia and other alkalies. The red colour is restored by acids.

portions of meadow. After the lapse of a couple of days, it was found that the colour of the litmus had perceptibly changed in each of the bell glasses, but most on the guanoed portions of the land. At the time of making these experiments the wind was N.E., and the temperature very low.

The grass exhibited little or no signs of growth.

We infer from these experiments that there is generally a slight escape of ammonia into the air from grass land, *manured* or *unmanured*, in those seasons of the year when there is no great activity in vegetable life.*

EXPERIMENT VII.

A portion of the mixture of soil and guano in the third experiment was placed in a filter paper, and a quantity of pure distilled water was added. The liquid which filtered through was neutral to litmus paper. On being tested, however, in the usual way with hydrate of lime, every precaution being taken, the litmus paper was readily turned blue.

From this experiment it is apparent that from a mixture of light soil and guano, in the proportion of 1,000 to 1, water is able to dissolve and remove a portion of the ammonia of the guano.

The difference of soils is not the only consideration; the climate of different localities in the British Islands is exceedingly various.

In Ireland, in Scotland, and in the Western districts of England, from Cornwall to Cumberland, the quantity of rain which falls in the year is probably nearly double that which descends in Suffolk, Norfolk, and on the East coast generally. The air also is constantly more humid, and for this reason those parts of our Isles are well adapted for the growth of root and green crops, and are not so well adapted for wheat. Guano may, consequently, at any time of the year, be there used in larger quantities, without the same danger of burning the crop, which would occur in our Eastern Counties. In these latter districts, the guano should

* These experiments require to be repeated on various soils, to enable us to draw from them more general truths.

never be applied as a top-dressing in dry weather, but during a wet or showery day.

Where wheat is grown in humid climates, it is liable to lodge before harvest, and therefore guano, if used, should be applied with caution to this crop. Two or three cwt. per acre, mixed with four cwt. of salt, is quite sufficient, one half at sowing, and the other in the spring.

From these and various other ascertained facts, we may deduce the following general rules for regulating the application of guano:—

GENERAL RULES FOR USING GUANO.

1st. That guano is best applied in damp or showery weather.

2nd. That guano should not generally be put on grass land in the spring later than April.

3rd. That when guano is applied to arable land, it should immediately be mixed with the soil, either by harrowing or otherwise.

4th. That when wheat is sown very early in the autumn, a less than usual amount of guano must at that time be applied, and the rest in the spring. The wheat, otherwise, might become too luxuriant, and be injured by subsequent frosts.

5th. That guano, and artificial manures in general, should be put on the land only in quantities sufficient for the particular crop intended to be grown, and not with the intention of assisting the succeeding one. Each crop should be separately manured.

6th. That guano, before application, should be mixed with at least from five to six times its weight of ashes, charcoal, salt, or fine soil.

7th. The guano should on no account be allowed to come in direct contact with the seed.

The preceding rules, if duly attended to, will prevent the recurrence of most of those vexatious losses of time and capital, which many, even of our best farmers, have experienced from want of a due acquaintance with the properties of concentrated manures.

In order still further to guard against disappointment arising from the misapplication of guano, we shall now describe the best practical modes of its application to the principal crops which are grown in this country.

MODE OF APPLYING GUANO TO VARIOUS CROPS.

PREPARATION OF GUANO FOR SOWING OR DRILLING.

For drilling, it must first be mixed with four to six times its weight of the ashes * of wood, turf, or coal, or with the same quantity of well sifted mould or salt. Charcoal, in powder, either from peat or wood, is also a most excellent article to be mixed with the guano, in the proportions indicated. Its great porosity allows it to retain the volatile ammonia, and, in dry weather, to absorb considerable moisture from the air. This is of material benefit to plants in their early growth.

Before mixing, the guano must be finely pulverised, which may easily be done with a common garden roller, upon the floor of a barn or shed, or even by blows from a common shovel. A layer of the ashes, &c., is then spread evenly upon the floor, and a quantity of the fine guano sifted over it. This is followed by another layer of mould or ashes, and another of guano, until the requisite quantity of both is used. The whole must then be repeatedly turned with the shovel, until thoroughly mixed. If time will permit, it is now preferable to leave the mixture for eight or ten days. It must then be again sifted, when it will be ready for use.

* Some varieties of wood ashes, which contain a considerable amount of free alkali, are not suitable for mixing with guano, as they liberate the ammonia. This may easily be shown by mixing a shovel full of the ashes with the same quantity of guano. If a strong ammoniacal odour be immediately perceived, the ashes are not fit to be mixed with guano. The mode of preparation here described should be used, with slight variations, according to circumstances, for all varieties of crops —J. C. N.

In using guano with the drill, care must be taken that the mixture fall below the seed, and that an inch or so of soil intervene between them, otherwise the strength of the guano will kill the seed. Garrett's, Hornsby's, and other modern drills, are well adapted for depositing guano and other concentrated manures.

The above mixture is generally sufficiently damp to fall exactly where the hand directs it. When this is not the case, a small quantity of water must be added; the field must be sown with the mixture in the ordinary manner, and the manure harrowed in; the seed is then drilled as usual.

Perhaps the preferable mode would be, to broadcast two-thirds of the guano applied, and to drill one-third with the seed. The young plants would then have enough manure under the drills to serve the early stages of growth, while the guano sown broadcast would supply the wants of the plants in a more mature state, when the roots would have spread in every direction in the soil.

WHEAT, BARLEY, OATS, AND OTHER CEREALS.

The researches of modern chemistry have in no respect proved of greater benefit to practical agriculture, than in the analysis and estimation of the components of different manures, and in the careful examination of the effects of these components on different crops, when applied either alone or combined. This is, in fact, the only philosophical mode of arriving at a true knowledge of the manuring substances best adapted for the development of various forms of vegetable life.

From the analyses of thousands of samples of manure in the laboratories of the college, and from a knowledge of the effects produced by these manures on a variety of crops, the conclusion has been irresistible, that NITROGEN is the cheapest substance to apply to cereals. The same conclusion has been arrived at by numerous other chemists. The results also of the experience of farmers in all parts of the country, for many years, is, that nitrogen, in any of its ordinary combinations, is the matter of all others best adapted for the growth of wheat and other cereals, and which for these crops will yield the greatest per centage of profit.

Not that corn requires no phosphates or other materials for its development, but that the latter are generally supplied to the soil for other crops in the ordinary course of rotation, or, as in the case of guano, are found in the manure itself. The market value of nitrogen of course varies with the source of its supply, and with the rise and fall in price of its various combinations; but at the present comparative price of guano, this substance appears to be nearly, if not altogether, the cheapest source of nitrogen, at least in any considerable quantity.

There can be no doubt of the vastly increased production of corn, and consequently of profit to the farmer, which would accrue, if guano were more extensively used.

Our most intelligent agriculturists, among whom we may mention Mr. Caird and Mr. Lawes, agree that the application of two cwt. per acre, will give an increase of between eight and nine bushels of grain, besides one fourth more straw than usual.

Mr. Caird * has proved that without any increase of rent or taxes, an expenditure of twenty shillings per acre produces a net profit of thirty-two shillings and sixpence. If these facts were more generally known, it is impossible to believe that farmers would not at once avail themselves of the opportunity of making a profit of more than one hundred and fifty per cent. upon the annual additional outlay.

Many farmers prefer using the whole of their guano for wheat in the autumn. A portion, at all events, should be sown *broadcast* at that period. This is more especially needful if no dressing of farm-yard dung be used.

If guano be used for wheat, in lieu of farm-yard dung, a greater quantity, often the whole, ought to be applied in the autumn. Care, however, must be taken not to stimulate the plant too much, otherwise it will be liable to suffer injury from frost. One cwt. or two cwt. per acre on light lands can be applied broadcast, and harrowed in during autumn, either before or after the drilling of the wheat.

* See Mr. Caird's Letter, at the end of this Essay.

In the spring, a further application of not more than one cwt. or two cwt. may be made, harrowed in with light harrows. If the wheat be drilled sufficiently apart to allow of horse-hoeing, it will be found advantageous.

Should wheat, manured with dung as usual, look unkindly in the spring, it will be greatly benefited by a dressing per acre of two cwt. of guano, and four cwt. of salt. Salt has great effect in strengthening the straw of wheat and other cereals, and where any of these crops are liable to lodge, or whenever guano is used, four cwt. or five cwt. of salt should always be sown per acre. For barley and oats, two cwt. of guano, and four cwt. of salt, may be sown broadcast per acre, the seed drilled, and the whole harrowed in together.

TURNIPS.

For this crop guano may be applied, either broadcast or by drill, mixed as previously shown. The quantity of guano to be used per acre will vary with the condition of the farm. About two to three cwt. may be applied with advantage, and six cwt. have been used with safety on heavy soils. Two cwt. or three cwt. sown broadcast, and one cwt. drilled with the seed, will probably give the best chance for a successful result.

Experiments have proved that, when a portion of guano is applied between the drills, and well horse-hoed in after the turnips are up, that large crops are obtained. It is questionable whether this is not one of the best means of applying guano, as on light soils there is less liability to loss in the guano, and the roots of the turnip are supplied with fresh manure at a vigorous period of their growth. Two cwt. or three cwt. broadcast before the turnips are sown, and one cwt. between the drills afterwards, will be found sufficient.

A combination of superphosphate of lime with guano has been used with much success. For this purpose, two cwt. or three cwt. of guano is sown broadcast, and the same quantity of superphosphate of lime, mixed with ashes, drilled with the seed.*

* The prize for the best forty acres of Swedes in one of our most important agricultural counties, was taken by a gentleman who followed this plan.

We may here suggest to some of our intelligent practical farmers, to try the effect upon the turnip crop of a mixture of Peruvian guano and sulphuric acid.

Sulphuric acid is undoubtedly a manure *per se*, and it seems to exert a specific effect on the turnip. A mixture might be made of four cwt. of guano, and one cwt. of white acid, of sp. gr. 1.84. The guano must be laid in a heap, a hollow made in the centre, and the sulphuric acid must be poured into it; the whole should then be well worked together with a spade or other instrument. Considerable chemical action will take place, but in a short time the whole will become dry and ready for the drill. If the brown acid, of sp. gr. 1.7, be employed instead of the white, one-fourth more must be used. The above quantity will be sufficient for two acres. We believe that a mixture of this kind will prove a most efficient manure.

It is of some importance to remember, that in using guano for turnips and other roots, that the whole of the nitrogenous matter is not taken out by the crop, but that a portion is left for the subsequent corn crop. Large quantities of guano are used for heavy land, by many of our best Essex farmers, on mangel as a good preparation for wheat, the mangel being wholly withdrawn from the field.

MANGEL WURZEL.

Guano is an excellent manure for this crop. On heavy and loamy soils the land is ploughed, and ten or twenty tons of farmyard dung are worked into the soil—before Christmas, if possible. Two or three weeks before drilling the seed, four cwt. of guano, with an equal weight of common salt, is sown broadcast over the field and well harrowed in. The seed is drilled in the usual way, and at thirty to forty inches apart. In thinning the plants afterwards, they should not be left too close together. Repeated horse-hoeings between the rows is of great importance, for air and nutriment are thus admitted to the roots of the plants. As in the case of the turnips, great advantage will be obtained by occasionally sprinkling a little guano between the rows previously to the hoeing. This insures continued nutriment to the plants.

When no farm-yard dung has been applied in winter, six cwt. of guano may be used instead of four cwt. On heavy land this may be put on either in the autumn or spring, and well worked into the soil, following this up by a small dressing afterwards between the drills at the time of hoeing. The land in either case will be left in good condition for wheat.

On light chalky soils, a mixture of guano, nitrate of soda, and common salt, at the rate of two cwt. each per acre, has been found very efficacious in the growth of mangel wurzel.

GRASS.

The experiments of Kuhlmann, the French Agricultural Chemist, upon the action of ammonia on grass lands, at once point to guano as one of the most important manures for increasing the productive power of our pasture and meadow land. This chemist applied ammonia in different forms, alone and combined with other simple mineral manures, and he found that in all cases the amount of grass or hay produced was in exact proportion to the amount of nitrogen contained in the manure. Guano containing a large amount of ammonia, and being also, at present, its cheapest source, must, therefore, prove of great benefit in the production of grass.

For grass land, from two to four cwt. of guano, mixed with soil, may be used per acre. Wet or damp weather should be selected for sowing it. Probably the end of March or the beginning of April is the best time. Under certain circumstances, guano may be applied to grass land in the autumn, particularly where the under soil is of a strong or loamy character. Thus applied, it will have the effect of bringing up the grass earlier in the spring.

POTATOES.

From the comparison of numerous series of experiments, it would appear that guano succeeds best with this crop as a top-dressing, in conjunction with farm-yard dung. The ground is prepared in the usual manner. The farm-yard dung is deposited in the bottoms of the drills, the sets of the seed potatoes laid upon the top of the manure, and the whole earthed up. Before the plants appear, the guano is to be sown on the top of the drills, covered over with the plough, and then rolled. If the potatoes be grown on the level, and not in drills, the guano may be sown over the field broadcast, two or three weeks after the potatoes have been planted. The quantity of guano to be used per acre is from three cwt. to six cwt.

Many experiments have proved the great utility of sulphate of soda, or sulphate of magnesia, in conjunction with guano, upon this crop. As far as our own experience goes, these salts have a decided effect in diminishing the liability of potatoes to disease. We should, therefore, recommend, in addition to the guano, to put per acre, at the same time,

1 cwt. of sulphate of soda, and
1 cwt. of sulphate of magnesia.

If farm-yard dung be not used for potatoes, broadcast and harrow in three cwt. or four cwt. of guano, and set the potatoes as usual. Three or four weeks afterwards, sow over them, and lightly harrow in, the same quantity of guano, and one cwt. each of the sulphates of soda and magnesia.

The mixture of sulphuric acid and guano mentioned at page 99, under the head of turnips, would probably be found an excellent manure for this crop.

Near the Humber, as much as ten cwt. annually is used for potatoes, with extraordinary results.

BEANS, PEAS, AND LEGUMINOUS PLANTS.

For beans or peas, two cwt. or three cwt. per acre may be used, either broadcast before sowing, or a portion afterwards between the drills at the time of horse-hoeing. The latter would probably be the better plan.

For vetches, lucerne, saintfoin, or clover, two cwt. or three cwt.

per acre broadcast may be used. This should be sown in the beginning of April, on a dewy morning, or during wet weather. It is useless to sow if there be a probability of dry weather ensuing for any lengthened period.

FLAX.

This crop, in olden time, had the renown of being one of the most exhausting crops which could be put into the land. We have now learned that white crops, and those in general which have the repute of "*drawing the land*," are those which require the largest amount of nitrogen for the formation of seed, and for which, consequently, ammoniacal manures are precisely adapted. With the aid of guano, or other ammoniacal manures, flax can no longer be considered an exhauster of the soil.

In using guano for this crop, from two cwt. to four cwt. per acre, mixed with ashes, may be sown broadcast and harrowed in, a few days before the seed is drilled.

CABBAGE, CARROTS, &c.

Guano has been found of material benefit for these crops, and may be employed advantageously at the rate of from two cwt. to four cwt. per acre. It must be remembered that carrots require deep cultivation, and that both crops will be benefited by the proper stirring of the soil between the rows, and the occasional addition of a little guano.

HOPS.

To no crop does the addition of a proper amount of ammoniacal manure prove more advantageous than to the hop. The constant withdrawing of the hops, year by year, from the land, necessitates the importation upon the soil of a considerable amount of both mineral and organic ingredients. Four cwt. of guano and three cwt. of salt per acre, applied at two separate times, and well worked in between the alleys, will be found a useful application. Or the manure may be put round each hill, and covered up with the soil.

From several analyses of the hop plant, the following mixture was recommended by the Author, some years ago, as a proper manure for the hop:—

MANURE FOR AN ACRE OF HOPS.

3 cwt. of guano,
1 cwt. common salt,
1½ cwt. saltpetre, or nitrate of soda,
1 cwt. gypsum.

This manure has been used with considerable success in various parts of Surrey, Kent, and Sussex.

It will not be necessary to give any further details of particular crops for which guano is suitable, or to describe more fully the mode of its employment. The intelligent farmer will soon learn to vary its application to suit the end he may have in view.

Guano, however, is useful to others besides the farmer. To the horticulturist it is invaluable, and many specimens of the finest vegetables and fruits, and of the most beautiful flowers, have been indebted to the judicious use of guano for the admiration they have excited, and the prizes they have obtained.

For further particulars respecting its horticultural use, we must refer the reader to the columns of the "Gardeners' Chronicle." And in concluding this part of our subject, we cannot refrain from quoting the opinion of Dr. Lindley, the learned editor of that valuable journal, that "If the experience of the last few years has taught us one thing more certainly than another, it is the unfailing excellence of guano for every kind of crop *which requires manure*."

THE COMPOSITION OF GUANO.

Our space will not permit us to describe all the varieties of proximate elements contained in different samples of guano. Nor is it, indeed, necessary for the practical man to be acquainted with them, as the commercial value of guanos is best determined by the amount of nitrogen (ammonia) and phosphate of lime they contain.

For more minute information on this subject, the reader is referred to Dr. Ure's paper on guano, in Vol. V. of the "Journal of the Royal Agricultural Society."

In this inquiry we have devoted our observations more especially to the Peruvian guano, as the quantity of this article at present brought into the market very far exceeds that of all the other kinds of guano put together.

A word or two may not, however, be out of place respecting the other varieties, the principal of which are the Angamos, the Chilian, the Bolivian, the Saldanha Bay, and the Australian. The island of Ichaboe, on the African coast, furnished a few years back large supplies of a medium guano. It is now, we believe, wholly exhausted.

The Angamos guano is from the western coasts of South America. It is the most recent deposit of the birds, collected by hand, with considerable danger and difficulty, from the bare surfaces of the precipitous rocks which they frequent. When pure, it is of first-rate quality, and having suffered no decomposition, frequently contains from 20 to 24 per cent. of ammonia. The smallness of the quantity, however, that can be collected, renders it of little general importance to the farmer.

The Saldanha Bay, and other varieties, having been deposited in rainy climates, have suffered great deterioration. The valuable ammoniacal salts and soluble phosphates have been in great measure washed away, the nitrogenous animal matter has been decomposed, and little remains but the common phosphate of lime. The Chilian and Bolivian are often contaminated with large quantities of sand, and the Shark's Bay (Australian) guano, is certainly not worth the carriage to this country. The farmer ought at no time to buy any of these descriptions of guano without an accurate analysis, as, owing to their varying impurities, it is otherwise possible that he may pay for them several pounds per ton above their real value.

An idea of the great difference of composition which exists in samples of guano from distinct localities, can only be formed by a comparison of their respective analyses. To enable the agriculturist to form a correct judgment of the kinds now in the market, we give a table of the composition of six varieties.

ANALYSES OF DIFFERENT VARIETIES OF GUANO.

	Angamos Guano.	Angamos Guano.	Peruvian Guano.	Chilian Guano.	Bolivian Guano.	Saldanha Bay Guano.	Sharks' Bay Guano.
Moisture	10·90	12·55	9·30	20·46	16·00	17·92	14·47
Organic Matter, &c.	67·36	61·07	57·30	18·50	13·16	14·08	7·85
Sand, &c.	1·04	5·36	0·75	22·70	3·16	2·80	14·47
Phosphates	16·10	13·76	23·05	31·00	60·23	59·40	29·54
Alkaline Salts, &c ..	4·60	7·26	9·60	7·54	7·45	5·80	33·67*
	100·00	100·00	100·00	100·00	100·00	100·00	100·00
Nitrogen (equal to)	19·95	18·24	15·54	4·50	2·11	0·63	0·35
Ammonia	24·19	22·12	18·87	5·47	2·56	0·76	0·47

We may here caution the farmer not to put any trust in those analyses, often placed in his hands, which merely indicate that the sample analysed contains such and such a per-centage of *animal organic matter*, or of *salts of ammonia.*

From these deceptive analyses, it is perfectly impossible even for the most experienced chemist to obtain the slightest notion of the value of a manure; and we recommend the farmer, under no circumstances, to buy a guano, unless the precise amounts of *ammonia* and *phosphate of lime* are distinctly mentioned.

Should the farmer wish to prepare a sample, for chemical analysis, half a pound should be taken from each of five or six bags containing the bulk. These should be mixed together on a sheet of brown paper, until thoroughly incorporated and homogeneous. Two or three ounces of the mixture is enough for analysis; and it can easily be sent per post from any part of the kingdom. To prevent evaporation from the sample, it can be wrapped up in tinfoil, or lead leaf from a tea chest, and afterwards in paper. If the tinfoil cannot be procured, two thicknesses of strong paper should be used.

* 29·54 per cent. of this was gypsum. The above are analyses made in the Kennington Laboratories. The samples were from cargoes received in London within the last six months. The Chilian and Bolivian guanos are much inferior to those formerly imported, in consequence, we believe, of all the finer qualities having, for some time, been worked out.

In order to furnish a standard of comparison to the farmer who may think it desirable to ascertain the composition and value of the guano he purchases, we subjoin an analysis of an ordinary sample of Peruvian guano, recently imported.

Analysis of an average sample of Peruvian Guano.

Moisture		15·10
Organic Matter, &c.		51·27
Silica		2·20
Phosphate of Lime		22·13
Phosphoric Acid (*equal to*)		3·23
Phosphate of Lime	7·00	
Alkaline Salts, &c.		6·07
		100·00
Nitrogen		13·54 per cent.
Ammonia		16·42

ON THE ADULTERATION OF GUANO.

After the observations we have made on the utility of guano to those engaged in agricultural pursuits, it would have been very gratifying to have concluded our remarks.

It is, however, our invidious duty to refer to a less pleasing, but not less important, part of the subject.

The high manuring value of guano, and its extensive sale, combined with the want of knowledge among farmers as to the genuineness of the article, and their manifest reluctance to be at the expense of a chemical analysis, have, together, induced many fraudulent dealers to adulterate this manure systematically, to a great extent. The strong desire which unfortunately exists among a large class of farmers to purchase guano at the lowest terms per ton, without due reference to the quality or composition of the manure, has also operated most materially to their own disadvantage.

If the honest dealer offers a genuine article in the market, upon which he puts only a reasonable profit, and finds that his roguish neighbour can more readily sell an adulterated article, he has no alternative but to abandon the trade or to turn rogue himself. The man who likes *cheap* manures should be reminded that to the buyer they are always *dear*, as he has to pay the whole expense of adulteration, as well as the twenty or thirty per cent. profit of the dishonest dealer. In fact, we should recommend the lovers of cheap manures to follow, in preference, the example of Quin, who finding his milk more than half water, armed with two jugs, demanded of his milkman "to give him them *separate*, he could *mix* for himself."

It is, indeed, scarcely possible to give persons at a distance an idea of the extent to which guano is adulterated in London and some other large towns.

The demand of the farmer for *cheap* manure, acting upon the trade through the medium of the unscrupulous dealer, has given rise to a fraudulent and hitherto successful business.

A most extensive and profitable trade is at present carried on by parties who practise the compounding of specious-looking ARTICLES, to mix with guano; these they supply to dealers in that manure.

The materials used to sophisticate guano are numerous.

Sand, marl, clay and chalk, limestone, bricks, tiles, gypsum—ground, when necessary, to a fine powder—constitute the materials for which the farmer is destined to pay £8 or £10 per ton. The marls of Stratford, Wanstead, and other places in Essex, and the yellow loams of Norwood, in Surrey, are in particular request. These, mixed in proportions to counterfeit the colour of guano, are sold to roguish dealers in town and country, who *introduce a little genuine guano* to give the necessary odour. Some recent actions brought against parties who have sold adulterated guano, in which heavy damages were obtained, and the failure of several of the largest of the manufacturers of the "ARTICLE," have contributed some little to arrest this nefarious traffic. The real remedy lies with the farmer, who ought to prosecute vigorously those who impose upon him.

Though numerous unprincipled dealers exist in the manure trade, yet there are certainly many others, honest men, upon whose fair fame there has never yet been a breath of suspicion.

We advise the farmer, therefore, to purchase his manures from men of established reputation, who have a character to lose, and who will not demand from him more than a fair and reasonable profit.

It should also be remembered that £11 per ton is the lowest price at which Messrs. Ant. Gibbs and Sons sell Peruvian guano; and this only in wholesale quantities. The country dealer has, in addition, to pay wharfage, carriage and other expenses, which must be added to the cost of the guano. He is also entitled to a reasonable interest for his money, if he gives long credit for that manure which he himself is compelled to pay for in cash.

We leave it, therefore, to the common sense of the English farmer to judge whether a genuine guano can possibly be purchased at the prices at which guanos, *purporting to be genuine*, are constantly offered in the country markets.

To assist still further in preventing the frauds to which the incautious buyer is continually subject, we shall offer some simple observations on the methods of detecting adulterations in guano.

METHODS OF DETECTING THE ADULTERATION OF GUANO.

The chemical analysis of guano is, of course, the best means of ascertaining any fraudulent mixture which may have been made; and it is a subject of regret that few farmers yet avail themselves of chemical aid, though the expense of the necessary information is quite insignificant compared with the importance of the object to be attained.

It has long been a desideratum to obtain some method of ascertaining the purity of guano, sufficiently simple to be easily understood and put in practice by any person of ordinary intelligence. With this object in view, we have tried in our laboratory many long series of experiments. These have ultimately led us to propose a few simple tests, which will readily discover the adulterations in any sample of sophisticated guano which has yet appeared in the market.

As guano is generally adulterated with marls and sands, much heavier than itself, our attention was first directed to the specific gravity of guano as a means of detecting the admixture.

In a lecture delivered some time since before the London Farmers' Club, we had shown that an ounce of good guano, put into a cylindrical glass tube, occupied nearly twice the space of an equal weight of an adulterated sample. We subsequently tried many hundreds of experiments with various guanos, in tubes of like dimensions, but though the tube easily detected all the adulterated samples we procured, yet it was thought desirable to propose some more delicate test.

Various other experiments were undertaken, and the following series gave us the necessary foundation for the method we ultimately selected.

A stoppered bottle, capable of holding 3,000 grains of water, had four ounces avoirdupois of good guano placed in it. Water was then added, and the materials shaken until well mixed. A little more water was added, and the bottle again agitated, and then allowed to rest for three or four minutes to permit the air bubbles to arise. The bottle was now filled completely with water, the froth running over; the stopper was then gently, but accurately, fitted to its place, and the bottle wiped with a cloth.

A counterpoise, previously made equal to the weight of the bottle alone, was then placed in one pan of a small pair of ordinary scales, and the bottle, with the guano, in the other. From a numerous series of experiments, it was found that the bottle and guano, on an average, weighed 664 grains more than the bottle and water alone: that is, the water in the bottle would weigh 3,000 grains, and the guano and water 3,664 grains.

The following table contains the results of a long series of experiments made upon specimens of genuine guano obtained from separate vessels, and also upon various sophisticated samples, and substances used for adulteration.

WEIGHTS INDICATED BY GUANO TESTER.

The Bottle holding 3,000 grains of water.

	oz.	Name of Vessel.	Grains.
1	4	Field	3663
2	4	Columbia	3662
3	4	Princess Victoria	3668
4	4	Digby	3665
5	4	Liskeard	3655
6	4	Duncan Ritchie	3669
7	4	Rosina	3677
8	4	Mary Ann	3668
9	4	Albyn	3679
10	4	Johann George	3661
11	4	Rosamond	3645
12	4	Ann Dashwood	3648
13	4	Alfred	3645
14	4	Juno	3659
15	4	Brothers	3665
16	4	Richardson	3641
17	4	Hamilton	3679
18	4	Anna	3677
19	4	Midas	3659
20	4	Will Willmot	3659
21	4	Macdonell	3653
22	4	Cumberland	3651
23	4	Retriever	3677
24	4	Lacy	3677
25	4	Vigilant	3669
26	4	Julius Cæsar (damaged)	3719
27	4	Vicar of Bray (damaged)	3703
28	4	Field, adulterated 10 per cent.	3709
29	4	Ditto 20 per cent.	3757
30	4	Ditto 30 per cent.	3815
31	4	Guano, £7 10s. per ton (adulterated)	3867
32	4	Guano, £7 12s. 6d. per ton (ditto)	3894
33	4	Salt	3930
34	4	Sand	4095
35	4	Gypsum	4065

The per centage of mineral matter or ash in different samples of guano was found also very uniform, varying, as the following table shows, only from 30 per cent. to 35 per cent.

Table of the per Centage of Mineral Matter contained in Peruvian Guano.

	Name of Vessel.	Per cent. of Ash.
1	Johann George	33·4
2	Ann Dashwood	32·2
3	Alfred	32·0
4	Juno	32·3
5	Brothers	33·2
6	Richardson	30·7
7	Hamilton	33·4
8	Anna	32·5
9	Midas	33·0
10	Will Willmot	34·0
11	Macdonell	33·1
12	Cumberland	32·3
13	Retriever	31·9
14	Lucy	31·8
15	Vigilant	33·5
16	Rosamond	35·0
17	Julius Cæsar (damaged)	38·2
18	Success (dito)	33·6
19	Guano, £7 10s. per ton (adulterated)	62·7
20	Guano, £7 12s. per ton (ditto)	65·8

From the experiments detailed on page 110, is deduced the following simple plan, which will easily detect all the ordinary adulterations of guano.

Procure from any druggist a common wide-mouthed bottle with a *solid* glass stopper; one known as a wide-mouthed six-ounce bottle will do very well. Let this bottle be filled with ordinary water, the stopper inserted, and the exterior well dried. The scales to be used ought to turn well with a couple of grains. In one pan of the scales place the bottle, and exactly counterpoise it in the other by shot, sand, or gravel. Remove the bottle from the scale, pour out two-thirds of the water, and put in four ounces avoirdupois of the guano to be tested. Agitate the bottle, adding now and then a little more water; let it rest a couple of minutes, and fill with water, so that all the froth escapes from the bottle; insert the stopper carefully, wipe dry, and place the bottle in the same scale from which it was taken. Add now to the counterpoised scale one-and-a-half ounce avoirdupois, and a fourpenny piece, and if the bottle prove the heavier, the guano is, in all probability, adulterated. Add in addition a threepenny piece to the counterpoise, and if the bottle and the guano prove the heavier, the guano may be considered as adulterated. By this simple experiment, the admixture of a very small amount of sand, marl, &c., is distinctly shown.

We venture also to propose another method, founded on the properties of the mineral constituents of guano. When guano is burnt to ashes at a red heat, the ash has a pearly white appearance, which is owing to the absence of iron and other colouring metallic oxides.

As iron is always found in marl, clay, &c., the ash of any sample of guano contaminated with them will not only be coloured, but its weight will be increased.

These facts give us the following method of detecting adulteration.

A small pair of scales, a little platinum capsule, a pair of little tongs or pincers, and a spirit lamp, are all that are required. Ten grains of the guano are placed in the platinum capsule, which is held by the tongs in the flame of the spirit lamp for several minutes, until the greater part of the organic matter is burnt away. It is allowed to cool for a short time, and a few drops of a strong solution of nitrate of ammonia added, to assist in consuming the carbon in the residue. The capsule is again gently heated (taking care to prevent its boiling over, or losing any of the ash), until the moisture is quite evaporated. A full red heat must then be given it, when, if the guano be pure, the ash will be pearly white, and will not exceed three-and-a-half grains in weight. If adulterated with sand, marl, &c., the ash will always be *coloured,* and will weigh more than three-and-a-half grains.

Even the simple burning of a few grains of guano, on a red-hot shovel, will often indicate by the colour whether a fraud has been committed; but we cannot particularly recommend this method, as the iron of the shovel will itself sometimes give a tinge to the ash.

It will be perceived, that the per centage of ash will not always detect damaged guano, nor are the tests generally intended to apply to wet or moist samples, which are palpably from damaged cargoes. Good Peruvian guano is perfectly dry to the touch.

If the adulteration be made with light or flocculent matters, they may be detected easily, as follows: Dissolve in a quart of water as much common salt as it will take up, and strain the solution. Pour a quantity of it into a saucer or basin, and sprinkle on the surface the guano to be tested. Good guano sinks almost immediately, leaving only a very slight scum. The adulterated leaves the light materials floating on the water.

If chalk or ground limestone be used, it may be shown by pouring strong vinegar over a teaspoonful of the sample placed in a wine glass. On stirring, effervescence shows its presence. Genuine guano, under the same circumstances, merely allows the escape of a few air bubbles.

If farmers could be prevailed upon to spend a small portion of their time in trying the foregoing simple experiments on the samples of guano they use, the fraternity of rogues would certainly have far less chance than they at present possess of pursuing their calling with profit. Still these little operations are only offered as a means of detecting the grosser adulterations of guano. Minor ones may still be practised, and men of real intelligence and business habits will regularly call to their assistance the aid of the analytical chemist.

Summing up the experiments, the following facts would appear:—

1st. If four oz. of guano, weighed with bottle and water, as previously directed, take more than one-and-a-half oz. and one fourpenny piece to recounterpoise it, its purity is doubtful. If an additional threepenny piece is required, the guano may be considered as adulterated, and the sample should be immediately analysed.

2nd. If the ash be coloured in any way, and not of a pearly white, the guano is bad.

3rd. If the ash of ten grains of the guano weigh more than three-and-a-half grains, or less than three grains, the genuineness of the sample is doubtful.

4th. If strong vinegar cause a considerable effervescence when mixed with the sample, the latter is adulterated.

5th. If the guano floats, when sprinkled on a strong solution of salt and water, it is not genuine.

Note.—A complete set of the Apparatus necessary for making the previous experiments, can be obtained at a moderate cost from Messrs. SIMPSON, MAULE, and NICHOLSON, Operative Chemists, 1 and 2, Kennington Road, London.

PRACTICAL EXPERIMENTS WITH GUANO.

Our limits will only permit us to introduce a few out of the numerous experiments made with this manure. For more extensive details, the reader is referred to the Journal of the Royal Agricultural Society, the Transactions of the Highland Society of Scotland, the Journal of the West of England Society, the Mark Lane Express, the Gardeners' Chronicle and Agricultural Gazette, Bell's Weekly Messenger, &c.

EXPERIMENTS OF MR. CAIRD.

Letter in the "Times," September 10th, 1853.

"The use of guano has been with me, as with many others for the last ten years, a matter of system, and I have frequently satisfied myself by experiment of the profit attending its application. To apply it to the wheat crop is the rule—not to apply it, the exception. Last autumn, in sowing a large field, exactly 100 acres, I directed the person who was laying on the guano to pass over an acre in the centre of the field, all the rest of which received two cwt. per acre, at the time the wheat was sown. The produce of this and the adjoining acre were cut, and kept separate from each other, and from the rest of the field, and were threshed last week, yielding as follows:—

	Bushels.		Cwt.
One acre, with two cwt. of guano	44	and straw	40
One acre, without guano	35	"	30
Increase of wheat	9	and straw	10

"The cost of the guano (Peruvian) on the field was 10s. per cwt., or £1 an acre, so that I have nine bushels of wheat for £1. The acre selected for the experiment was an average of the field, and I have no reason to doubt that for an expenditure of £100 on guano on that field last autumn, I have now reaped an increase produce of 900 bushels of wheat.

"This tallies very closely with the experience of Mr. Lawes in Hertfordshire, where two cwt. of guano gives an increase of eight bushels of wheat.

"The land on which the above experiment was made is a strong wheat soil of good quality, thoroughly tile-drained, sown in good order, after a bare fallow, on the 20th of September, and reaped on the 10th of August. The crop suffered no injury (possibly was benefited) by the heavy rains of last winter, which passed off through the soil to the drains as they fell. No manure but guano was applied; and this was the third application of guano on that field within the last six years.

"My experience in the south-west of Scotland, with that of Mr. Lawes in the south-east of England, shows that, in the climate of this country, *the application of two cwt. of Peruvian guano, on a duly-prepared wheat soil, will give an increase of one quarter of wheat.* The conditions, of course, must be observed, that the land is clean, dry, and in a fit state for the reception of the seed, which, if possible, should be sown not later than the 1st of October, and the guano must be applied, not as a top-dressing in spring, but be harrowed in along with the seed. There is no readier means within our knowledge of increasing the wheat crop. We may estimate the clays, or strictly wheat soils of England, to have 1,500,000 acres annually under wheat. This class of soil, as is well known, has for some years back been the least hopeful of any. The yield of wheat on such soils, after a clean fallow, probably does not exceed, on an average, two-and-a-half quarters an acre. For this all the costs of cultivation must be incurred—rent, taxes, seed, and labour; and I believe that, without increasing these necessary costs one farthing, and under the conditions already mentioned, an additional quarter of wheat may be reaped from each acre by an application of two cwt. of Peruvian guano.

"This is a matter of vast importance."

OTHER EXPERIMENTS OF MR. CAIRD.

"In the centre of a fifty-acre field, one acre was left without manure, all the rest of the field receiving two cwt. of Peruvian guano per acre in autumn, at the time the seed was sown. The produce of the acre undressed has been tested against that of the adjoining acre, which received Peruvian guano, and this is the result:—

One acre, with guano, 32 bushels, 63 lbs. weight per bushel, at 6s. 6d. per 60 lbs.	£10	18	4
One acre, without manure, 25½ bushels, 60 lbs. weight per bushel, at 6s. 6d. per 60 lbs.	8	5	9
	£2	12	7
Cost of two cwt. of guano in 1853	1	0	0
Profit per acre, besides one-fourth more straw	£1	12	7

"The inferiority in the quality of the unmanured wheat, as shown by the weight per bushel, is worthy of notice, as well as the fact that the unmanured wheat was a week later in ripening than the other."

EXPERIMENTS BY ROBERT MONTEITH, Esq., OF CARSTAIRS.

I.—Oat Crop, 1843.—Part of a field manured with 267 lbs. of guano, at the cost of 31s. per imperial acre, produced, per acre 59 bushels.

Manured with 10 bushels of bone-dust, at the cost of 23s. 4d. per imperial acre, produced, per acre, 43 bushels.

The difference may be stated as follows:—

Cost of Guano	31s. 0d.; produce, 59 bushels, at 2s. 6d.	£7	7	6
Cost of Bones	23s. 4d.; produce, 43 bushels, at 2s. 6d.	5	7	6
	7s. 8d.	2	0	0
	Deduct difference of manure	0	7	8
	Leaving in favour of guano	£1	12	4

II.—Hay Crop, 1843.—To part of a field, manured the previous year with farm-yard dung, was given 267 lbs. of guano per imperial acre, at the cost of 31s., and the *extra produce*, per acre, was 22 cwt. of hay.

Which, at 3s. per cwt., is	£3	6	0	
Deduct expense of guano	1	11	0	
Leaving in favour of guano.........	£1	15	0	per acre.

EXPERIMENTS BY GEORGE B. OSBORN, Esq.

Elburton, near Thornbury, Gloucestershire,
February 28th, 1844.

Gentlemen,

I beg to hand you the result of an experiment with guano purchased from you last May.

The total quantity cropped (to potatoes) was 3 a. 1 r. 18 p., of which 30 perches were manured with 131 lbs. of guano, at the rate of 6 cwt. 1 qr. per acre; the remaining portion had no manure.

The manured portion produced per acre	85	Sacks.
The unmanured ,,	52	,,
Total increase per acre	33	,,

The profit on one acre, would be—

	£	s.	d.
Increase per acre, 33 sacks at 5s..................	8	5	0
Cost of guano, carriage and additional labour	4	3	2
Clear profit per acre	4	1	10
Or, if kept to the present time, a profit per acre of	£5	14	10

The manured part produced by far the best sample; they were a week at least before the others, and retained, throughout the season, a marked difference.

The remaining portion of the guano I tried in several ways, and in all found it succeed; but I made no exact account of its efficacy. I intend trying it on a much larger scale next year, and feel sure it will yield a proportionate return.

I am, Gentlemen, yours obediently,

Messrs. Gibbs, Bright & Co. GEO. B. OSBORN.

EXPERIMENTS ON GRASS BY ALEX. CAMPBELL, Esq.

The following experiments were made in the year 1843, at the Botanic Gardens, Manchester, by Mr. Alex. Campbell.

APRIL EXPERIMENT.	RATE PER ACRE.						
	Produce, Grass.				Manure, Guano.		
	Tons.	cwt.	lbs.	oz.	Cwts.	lbs.	oz.
The produce of 1 square yard, on which 1 oz. guano mixed with ashes was spread, weighed 3 lbs.	6	9	72	0	2	78	8
The produce of 1 yard, on which 1½ oz. guano mixed with ashes was spread, weighed 3 lbs. 2 oz.	6	15	5	0	4	5	12
The produce of 1 yard, on which 2 oz. guano mixed with ashes was spread, weighed 3 lbs. 11½ oz.	8	0	78	12	5	45	0
The produce of 1 yard on which 2½ oz. guano mixed with ashes was spread, weighed 4 lbs. 4 oz.	9	3	74	0	6	84	4
The produce of 1 yard on which 3 oz. guano mixed with ashes was spread, weighed 4 lbs. 11 oz.	10	2	63	8	8	11	8
The produce of 1 yard on which 3½ oz. guano mixed with ashes was spread, weighed 5 lbs. 14 oz.	12	13	99	0	9	50	12
The produce of 1 yard on which 4 oz. guano mixed with ashes was spread, weighed 4 lbs. 10 oz.	9	19	92	0	10	90	0

These experiments are interesting, as showing a decrease in the production of grass when more than ten cwt. of guano was used per acre.

EXPERIMENTS UPON THE HAY CROP, BY R. OSBORN, Esq., BRUNSWICK LODGE, HENBURY.

Guano per Acre.	Grass per Perch.	Grass per Acre.				Hay per Acre.				Increase per Acre from use of Guano.			
		Tons.	cwt.	qrs.	lbs.	Tons.	cwt.	qrs.	lbs.	Tons.	cwt.	qrs.	lbs.
2 cwt.	105 lb.	7	10	0	0	2	7	0	21	0	17	3	25
4 ,,	155 ,,	11	1	1	20	3	9	2	18	2	0	1	22
None.	65 ,,	4	12	3	12	1	9	0	24				

EXPERIMENTS ON THE APPLICATION OF GUANO AND OTHER MANURES, IN THE DUKE OF DEVONSHIRE'S PARK AT STOVER, NEAR NEWTON ABBOT, DEVON. BY E. S. BEARNE.

No. I.—Report of an experiment to test the comparative efficiency of five different kinds of artificial manure in improving pond mud, the experiment being made on an acre of inferior pasture land in Stover Park, in the years 1847, 1848, and 1849. The land on which the experiment was conducted is of uniform quality, the land being of a light sandy loam a few inches in depth, incumbent on a stratum of white clay. The land underwent a thorough drainage in 1844, previous to which it would not produce a rent of more than 5s. per acre. No manures were applied to the land in 1848 or 1849. The object sought to be attained by extending the experiment over a period of three years, is to test the *durability* of the different manures.

TABLE I.

No.	Manures applied in 1847.	Weight of Hay cut in 1847.	Weight of Hay cut in 1848.	Weight of Hay cut in 1849.	Weight cut per acre in 1847.	Weight cut per acre in 1848.	Weight cut per acre in 1849.	Cost of the Manures.		
		lbs.	lbs.	lbs.	Seams of 3 cwt.	Seams of 3 cwt.	Seams of 3 cwt.	£	s.	d.
1	Six cubic yards of mud mixed with 6 cwt of Salt	312	327	613	$4\frac{2}{3}$	$4\frac{3}{4}$	9	0	14	0
2	Six cubic yards of mud mixed with $1\frac{1}{3}$ hogshead of Lime	353	337	538	$5\frac{1}{4}$	5	8	0	13	6
3	Six cubic yards of mud mixed with 3 bushels of Bonedust	511	419	670	$7\frac{1}{2}$	$6\frac{1}{4}$	10	0	14	3
4	Three cubic yards of mud mixed with 3 cubic yards of Tan-yard refuse	524	354	558	$7\frac{3}{4}$	$5\frac{1}{4}$	$8\frac{1}{3}$	0	14	0
5	Six cubic yards of mud mixed with 90 lbs. of Peruvian guano	930	550	725	$13\frac{3}{4}$	8	$10\frac{3}{4}$	0	14	0

N.B.—The after Grass in 1847 was stocked with sheep, but in 1848 it was left unconsumed.

No. II.—Report of an Experiment made with the undermentioned manures on an acre of pasture land in Stover Park, in the year 1849. The manures, when mixed with a small quantity of fine earth, were applied broadcast on March 29th, and during the rainy weather which prevailed at the time. The land is of a fair average quality, and was formerly used as tillage land, but has been in pasture for many years. The crops were mown on June 22nd, and the herbage produced by the different manures was of a superior quality.

TABLE II.

No.	Manures applied.	Quantity of Manures applied.	Quantity applied per acre.	Weight of Hay cut.	Weight cut per acre.	Cost of Manures.			Cost of the Manures per acre.		
		cwt.	cwt.	lbs.	Seams of 3 cwt.	£	s.	d.	£	s.	d.
1	None	..	..	401	$4\frac{3}{4}$	..	..	..	..	..	..
2	Superphosphate of Lime	$2\frac{1}{4}$	9	616	$7\frac{1}{3}$	0	18	0	3	12	0
3	Nitrate of Soda	1	4	706	$8\frac{1}{3}$	0	18	0	3	12	0
4	Peruvian Guano	$1\frac{1}{2}$	6	1210	$14\frac{1}{8}$	0	18	0	3	12	0

EXTRACT FROM A LETTER FROM J. M. PAINE, Esq., OF FARNHAM.

(*From the Gardener's Chronicle.*)

"As regards the application of ammonia to the cereal crops, I repeat that it is of no importance in what form it is given to the soil; therefore apply that which gives the largest per centage of ammonia for your money. At the present time Peruvian Guano (not adulterated rubbish), giving seventeen or eighteen per cent. of ammonia, is the cheapest source of supply. Last year, after a crop of pulled-off swedes, I put on three cwt. of Peruvian guano, mixed with the same quantity of phosphoric marl, per acre; and the result, as I have before stated, was a trifle over eight quarters of barley per acre; and in 1848, on a field of barley, after swedes fed off by sheep, and topdressed, when about six inches high, with eighty-four lbs. per acre of the sulphate of ammonia, mixed with two cwt. of phosphoric marl,* we omitted a few lands in different parts of the field, and we considered that we obtained from twelve to sixteen bushels more barley per acre on the top-manured portions. Last year my oat crop averaged full twelve quarters per acre; we have now just finished cutting this year's crop, and we expect to obtain an average of fourteen quarters. This crop is after turnips and swedes, about half of which were drawn from the field. When the oats were sown, four cwt. per acre of the guano and soot mixture with the fossil powder was applied. The land is naturally a poor gravelly clay, resting upon chalk. A neighbour of mine, upon a similar soil, after trenching it, applied six cwt. per acre of Peruvian guano, and his crop is about equal to my own; while another neighbour, in an adjoining field to my oats, who farms in the old fashioned way, will not grow much above a fifth of either

* The first discovery of the presence of phosphoric acid in the Farnham Marls was made by me in the year 1847; but no notice was taken of this fact in the paper which subsequently appeared on this subject in the 9th volume of the Journal of the Royal Agricultural Society, although the writers received the original information directly from myself.—J. C. N.

of our crops. I ought, perhaps, to add that we do not obtain a crop of weeds as well as corn, it being our object to have no trouble in cleansing our turnip fallows. If I had pulled off all my turnips, I should have doubled my artificial manuring for my oats. In manuring ammoniacally for wheat, if the soil were a clay or stiff loam, I would apply the whole dose in the autumn; if gravelly or chalky, half at the time of sowing, and the remainder early in March. In conclusion, when we have weak spots of corn in my fields, we mend them with guano in the spring."

OBSERVATIONS ON THE USE OF GUANO FOR GRASS AND HAY. BY PROFESSOR ANDERSON, GLASGOW.

Transactions of the Highland and Agricultural Society, March, 1856.

The superiority of guano is particularly evident, both from Mr. Porter's and Mr. M'Laren's experiments—the former obtaining by its use a produce exceeding that from nitrate of soda by almost exactly a fifth, and the latter by nearly a sixth. Mr. M'Laren's experiments have the additional importance of showing the greater slowness and permanence of action of guano, which appears to have produced upon the second crop of hay a considerably greater effect than it did upon the first. The conclusion to which we are thus brought is in perfect accordance with theory, for it is to be observed that the manures employed were taken so as to supply the same quantity of nitrogen, irrespective of their other constituents; and so, as their effect is dependent upon that substance alone, it seems to be immaterial whether it be in the state of ammonia or nitric acid. But Peruvian guano produces a greater manurial effect, because it supplies phosphates and alkaline salts, in addition to nitrogen; and hence its composition justifies the title of a "TRUE MANURE," applied to it by Mr. M'Laren.

APPROXIMATE ESTIMATION OF THE VALUE OF MANURES.

In consequence of the variation in the composition of manure, and the constant adulterations practised by unprincipled dealers, it is a matter of considerable importance to the farmer to be able in an easy manner to obtain an approximative value of any manure which he may have subjected to analysis; and we subjoin a mode of valuation, the use of which will at least save him from the gross imposition to which he is at present subjected. The substances which analysis and practice have proved to be most efficient as manuring principles are phosphates, and nitrogen in any of its forms.

A few isolated experiments prove potash to be of some value to one or two crops; but, as this substance can readily be bought in a state of tolerable purity as sulphate or muriate of potash, and as it is not generally found in compounded manures, we shall not give this any agricultural value, further than as comprised under the term of alkaline salts.

Silica, under any of its forms, has not yet been proved to have any agricultural value; and carbonate of lime (chalk) is in most instances a serious detriment to a manure, though useful on the large scale, when used per acre by tons at a time.

From a careful comparison of numerous analyses of manure with the value of the substances therein contained, we have been led to adopt the following prices as giving the nearest approximative value of the several manuring matters:—

	Multipliers of Value.
Nitrogen	£74 per Ton.
Ammonia	60 ,,
Phosphate of lime . . .	8 ,,
Phosphate of Lime made soluble	24 ,,
Organic matter	1 ,,
Alkaline salts	1 ,,
Sulphate of lime (gypsum) .	1 ,,
Silica	No value.
Carbonate of lime . .	No value.

The following mode of calculation has been adopted by me for many years, and is exceedingly simple, as we only require the analysis of the sample to enable us to arrive at its worth in a very few figures:—

RULE FOR CALCULATING THE VALUE OF MANURES.

Consider the analysis to represent the components of one hundred tons. Multiply the respective amounts of each ingredient by its price per ton in the preceding table, add up the several products, and the sum will represent the value of one hundred tons. Divide this amount by one hundred, and the quotient will be the price per ton.

The decimals in the analysis below 0.5 may be disregarded, and those above that amount reckoned as an additional unit. Thus, in the second example, the organic matter, instead of 21.68, may be read 22; and the phosphate of lime, instead of 44.35, may be called 44.

EXAMPLES.

I. VALUATION OF AN AVERAGE SAMPLE OF PERUVIAN GUANO.

		Value per Ton.		Total.
Moisture	15·10			
Organic Matter	51·27	× £1	=	51
Silica	2·20			
Phosphate of Lime . . .	22·13	× £8	=	176
Phosphoric Acid . . .	3·23			
=Phosphate of Lime (made Soluble)	7·00	× £24	=	168
Alkaline Salts, &c. . . .	6·07	× £1	=	6
	100·00			
Nitrogen (*equal to*) . . .	13·54 per cent.			
Ammonia	16·42	× £60	=	960
				1,00)£13,61
				20
Value £13, 12s. per ton.				12·20

II. VALUATION OF SAMPLE OF BOLIVIAN GUANO.

			Value per Ton.		Total.
Moisture	13·85				
Organic Matter	21·68	×	£1	=	£22
Silica	2·70				
Phosphate of Lime	44·35	×	£8	=	352
Phosphoric Acid	3·30				
=Neutral Phosphate (made Soluble) 7·15		×	£24	=	168
Alkaline Salts	14·12	×	£1	=	14
	100·00				
Ammonia	4·02	×	£60	=	240
					1,00)£7,96
					20
Value £7, 19s. per ton.					19.20

III. VALUATION OF A GOOD SAMPLE OF SUPERPHOSPHATE OF LIME.

			Value per Ton.		Total.
Moisture	19·82				
Organic Matter	20·72	×	£1	=	£21
Silica	2·80				
Soluble Phosphate	10·25				
=Neutral Phosphate (made Soluble) 16·00		×	£24	=	384
Insoluble Phosphate	16·60	×	£8	=	136
Hydrated Sulphate of Lime	29·81	×	£1	=	30
	100·00				
Ammonia	2·00	×	£60	=	120
					1,00)£6,91
					20
Value £6, 18s. per ton.					18·20

IV. VALUATION OF A BAD SAMPLE OF SUPERPHOSPHATE OF LIME.

			Value per Ton.		Total.
Moisture	17·90				
Organic Matter	14·00	×	£1	=	£14
Silica	29·10				
Oxide of Iron, &c.	8·62				
Soluble Phosphate	3·24				
=Neutral Phosphate (made Soluble) 5·05		×	£24	=	120
Insoluble Phosphate	3·85	×	£8	=	32
Hydrated Sulphate of Lime	23·29	×	£1	=	23
	100·00				
Ammonia	0·50	×	£60	=	30
					1,00)£2,19
					20
Value £2, 4s. per ton.					3·80

V. VALUATION OF ADULTERATED GUANO,* SOLD AS GENUINE PERUVIAN.

			Value per Ton.		Total.
Moisture	5·40				
Organic matter, &c. . . .	20·55	×	£1	=	£21
Sand	49·30				
Oxide of iron and alumina .	5·46				
Phosphate of lime . . .	16·25	×	£8	=	128
Carbonate of lime, &c. . .	3·04				
	100·00				
Nitrogen (*equal to*) . . .	4·65				
Ammonia	5·64	×	£60	=	360
Value £5 per Ton.					£5,09

* Often sold as Peruvian guano a pound or so under the market price, to farmers who are in want of—A BARGAIN.

VI. VALUATION OF A SUBSTANCE LATELY INTRODUCED INTO COMMERCE, CALLED "MEXICAN GUANO."

			Value per Ton.		Total.
Moisture	3·24				
Organic matter, &c. . . .	13·56	×	£1	=	£14
Silica	0·60				
Phosphate of lime . . .	25 60	×	£8	=	208
Carbonate of lime . . .	46·14				
Sulphate of lime, &c. . .	10·86	×	£1	=	11
	100·00				
Nitrogen (*equal to*) . : .	0·21				
Ammonia	0·26	×	£60	=	15
					£2,48
					20
Value £2, 9s. per Ton. †					9·60

† This value is, however, practically lessened by the large quantity of carbonate of lime contained in the sample. Yet this substance has actually been bought by farmers as guano at from £8 to £9 per ton.

The foregoing examples show how very closely the rule brings out all the actual value of the various samples. It is necessary, however, to remember that circumstances might possibly arise in the course of time, which would render some alteration necessary in the amounts of our multipliers of value. At the present period, however, they are sufficiently true for every practical purpose.

ON NITRIFICATION.

LETTER TO THE LATE PH. PUSEY, ESQ.

(*Journal of the Royal Agricultural Society, vol.* XIV., *page* 391.)

DEAR SIR,—At your request I subjoin a few observations on the conditions required for the formation of nitrates.

For some years, in my lectures, I have endeavoured to direct the attention of the farmer to the artificial formation of nitre, having felt somewhat surprised that its importance has hitherto been so generally overlooked.

I shall at present content myself with a brief explanation of the conditions under which NITRATES are formed. Whenever animal or vegetable matter—gaseous, liquid, or solid—containing nitrogen, comes into contact with *mild* calcareous or alkaline earths, the mixture being moist, and so porous that the air can easily penetrate, after some time the nitrogen, under certain conditions of temperature, is acted upon by the atmosphere, is oxidized, and is converted into nitric acid, which at once unites with the calcareous or alkaline bases present in the mixture.

The temperature most suitable is from 58° to 68° Fahr., and the action ceases at 32° Fahr., the freezing point.

The instances of the oxidation of gaseous nitrogenous bodies are very common. The mortar of almost all old buildings, in any situation, contains a greater or less amount of *nitrate of lime*, the nitric acid of which is produced by the oxidation of ammonia, absorbed by the mortar from the atmosphere. Another example is that furnished by an experiment of a French philosopher, who suspended a piece of moistened and well-washed chalk over a basin of putrifying blood, and who, after the lapse of some time, detected easily the presence of nitric acid in the chalk.

The oxidation of liquid nitrogenous compounds is also of ordinary occurrence. The urine of any animal mixed with calcareous or earthy matter readily furnishes nitrates by oxidation; and even the urinary deposits of animals on pastures in summer give rise to the formation of nitrates. The walls of stables and cowhouses, which by absorption have been moistened with urine, often give on their surfaces efflorescences of nitre.

The conversion into nitric acid of the nitrogen of solid animal or vegetable matters, constantly occurs when these bodies are in contact with earthy calcareous matters. Even in the absence of calcareous substances, nitric acid is formed in such common dung-heaps as consist merely of decomposing animal and vegetable matter; for one part of the ammonia produced by ordinary decomposition acts as the alkaline base to another portion, which by oxidation is converted into nitric acid. Nitrate of ammonia may always be found in dung-heaps. Nitrates are also present in all shallow wells adjacent to *church-yards*, and in those which derive their liquid supplies from strata into which cesspools empty themselves.

The proper conditions for the formation of *nitrates* are always to be found in well-drained and well-manured fields, particularly when they contain calcareous matter. One of the great uses of liming is to furnish the alkaline matter where it is deficient. In our laboratories we have examined a great number of soils, and in almost every instance have detected the presence of nitre.

In my opinion, a proper knowledge of the mode of forming nitre beds would be of considerable importance to the farmer; for by their use not only would he be able to conserve the ammonia of his manure when he had more of the latter than he could at once apply to the land, but by using the liquid manure from the tanks, the necessary moisture would be given to the heap; and whilst the aqueous particles, so expensive to carry, would gradually evaporate, the valuable matters of the liquid would be retained in the compost.

The mode of making artificial nitre-beds has been shortly described in my lecture to which you refer. It is exceedingly simple. A layer of calcareous matter forms the base of the heap, and layers of horse-dung, cow-dung, carrion, or other similar matters, alternating with layers of marl, mortar, or *spent* lime, will constitute the nitre-bed. The mixture should always be kept moist with urine, or urine and water; but too much water, as from rain, would be injurious, and the heap ought therefore to be kept under cover. The compost should lie as loosely as possible together, that the air may be easily able to permeate the mass. The heap should be thoroughly incorporated, and lightly turned over once in two or three months. In from six to nine months it will be ready for the farmer's use. *Quick lime* ought not to be used in making nitre-beds, as its first and most powerful action is to drive off the ammonia from the manure.

It must be understood that, by making mixtures calculated to give rise to the artificial production of nitrates, we have a means of preventing the loss of ammonia which takes place in a common dung-heap; and that, under ordinary circumstances, manures containing either nitrates or ammonia, without any important amount of other substances, are valuable exactly in proportion to the amount of nitrogen they contain. It may be necessary to mention, that in soils and dung-heaps the nitric acid produced by oxidation of ammonia *is re-converted* into ammonia when putrefaction is taking place, and *access of air is prevented*.

In conclusion, I may mention that I have analysed a portion of a large nitre-bed of about forty tons, which was (about ten months since) made on the premises attached to the College at Kennington. Though the heap has been exposed to all the rains of the season, it was found that one pound weight of the compost contained twenty-one grains of nitric acid, which is equivalent to thirty-four grains of saltpetre. This is an amount much below what we should have found had we had the heap under cover.

I am, my dear Sir, yours very truly,

J. C. NESBIT.

College of Agriculture and Chemistry,
Kennington, Dec. 13, 1853.

Henry Vizetelly, Printer and Engraver, Gough Square, Fleet Street, London.