GEORGICAL

ESSAYS.

To face the title of Vol. 1.

Barker sc. York.

GEORGICAL

ESSAYS:

BY

A. HUNTER, M. D. F. R. S. L. & E.

NISI UTILE EST QUOD FACIMUS STULTA EST GLORIA. *Phæd.*

VOLUME I.

YORK:

Printed by T. Wilson and R. Spence, High Ousegate,
FOR THE AUTHOR;
And sold by J. Mawman, Poultry; Cadell, jun. and Davies, Strand, and B. & J. White, Fleetstreet, London: Wilson and Spence, J. Todd, Sotheran & Son, and J. Wolstenholme, York; A. Constable, Edinburgh; and J. Archer, Dublin.

1803.

TO

THE YEOMANRY

OF

GREAT BRITAIN AND IRELAND

ON WHOSE EXERTIONS

DEPEND

THE WEALTH STRENGTH AND PROSPERITY

OF THE UNITED KINGDOMS

THESE ESSAYS

ARE INSCRIBED

BY

THE EDITOR.

PREFACE.

ABOUT the year 1770, a few gentlemen formed themselves into a society at York, for the purpose of giving encouragement to the Agriculture of their respective neighbourhoods; and in order to confer stability and reputation upon their undertaking, they took upon themselves the title of the YORK AGRICULTURE SOCIETY, with a President, two Vice-Presidents, a Treasurer, and Secretary. Convinced that respectability was unattainable without responsibility, the Society agreed to affix their respective signatures to all the papers read at their Board, and they also agreed that such papers as were thought to poſseſs distinguished merit, should be published in a work bearing the title of GEORGICAL ESSAYS. In about twelve months from the commencement of the Institution, the first volume made its appearance, and under the most favourable circumstances, the Society were induced to promise a continuation of the work; but in consequence of the death of many of the most active members, the publication was discontinued, so that only one volume exists to record the industry and attention of the York Agriculture Society. The Society is now no more, its dissolution having taken place about eighteen years ago. Having had a principal share in the publication of the GEORGICAL ESSAYS, I feel myself called upon not to suffer them to pass into oblivion; and I the more willingly engage in the undertaking, as I mean to make it the basis of a more extensive publication. It is my intention to draw into one focus, all that is widely diffused through numberless volumes of Agricultural information; and in so doing, I expect to be able to exhibit to the favourers of Agriculture, a field well cultivated—and free from all unsightly and noxious weeds. In this proposed collection there will be some papers that have never appeared in public; but by far the greatest number have been published in different periodical works. The distinguished authors of these papers will, I flatter myself, approve of my taking this method of rendering their public-spirited exertions more generally known; for it cannot be expected that a number of high-priced books, all of them containing some papers of useful information, can be the object of general purchase.

A. HUNTER.

YORK, MAY 1, 1802.

GEORGICAL ESSAYS.

BOOK I.

The Riſe and Progreſs of Agriculture.

AGRICULTURE is the oldest, as well as the most useful, of the arts. In the sacred writings we are told that Cain applied himself to husbandry, while Abel followed the peaceable life of a shepherd. The Patriarchs and their descendents spent their days in feeding of flocks and tilling the ground: but in those early ages the art was as simple as the manners of the people. They lived a wandering sort of life. Every new situation afforded them present support for their flocks; and whenever they met with a fruitful piece of ground, they usually rested upon it, and sowed their corn, which having reaped, they moved forward in quest of another habitation. This was the ſtate of Agriculture, when men had no other laws but those of God and Nature.

Among the Egyptians, a civilized nation, husbandry was regularly attended to; and it is extremely probable that the children of Israel, before they left that country, had made themselves, in some degree, acquainted with the manner of raising corn, and afterwards preserving it. As soon as their descendents had obtained the full and quiet poſseſsion of the promised land, they proceeded upon the plan of the old inhabitants, and became husbandmen.——Every man's poſseſsion having been allotted to him, Agriculture seems to have flourished amongst them, otherwise the land of Judea could not poſsibly have maintained the number of inhabitants that are recorded.

If we may credit the report of travellers, the land of Canaan is at present a barren and uncultivated country. The figurative expression of a land flowing with *milk* and *honey*, ſprung from the industry of the inhabitants cooperating with the natural fertility of the soil. It was in vain for the husbandman to expect a spontaneous growth of corn in the best of climates.

The Land of Promise was poſseſsed by a number of different nations. Among these the Phœnicians, or Philistines as they are called, were the richest and most industrious. They occupied a well-cultivated country bordering upon the sea. By means of their skill in navigation, they exchanged the superfluous product of their lands with the neighbouring nations. Their extensive commerce is sufficiently known. Being at last driven from their native country, they directed their course to the Mediterranean islands, and carried with them the art of husbandry.

In consequence of this migration, Agriculture became more diffused, and spread its influence over the neighbouring nations.

History informs us that the Greeks were once a most barbarous people. Pelasgus received divine honours for teaching them the use of acorns for food. A small colony from Egypt, or Phœnicia, instructed them in the manner of growing corn. The Athenians were the first that received the inestimable blessing. Humanity succeeded; and from that source the fine arts derived their origin.

The Romans had a laudable pride in being thought husbandmen. As early as the reign of Numa, public encouragement was given to Agriculture. Succeeding ages continued sensible of its utility. Sound policy informed them, that an extensive territory and a number of inhabitants did not always constitute a great and powerful people. They knew that the lands must be cultivated, and the inhabitants must be industrious, before that desirable event could be accomplished. When the Romans made the most illustrious appearance, husbandry was in the highest estimation among them. "In those happy days," says Pliny, "the "Earth, pleased at seeing herself cultivated by "victorious hands, seemed to make stronger "efforts, and to produce her fruits in greater "abundance."—But when destructive luxury was introduced, then husbandry declined, and with it fell all the Roman virtue.

The ancient writers give us excellent comments upon the husbandry of their times. Hesiod wrote very early upon Agriculture. Mago, the Carthagenian general, composed twenty-eight books upon the same subject, which were translated by order of the Roman Senate. Upon these models Virgil formed his elegant precepts of husbandry. Cato, the Censor, wrote a volume upon Agriculture. Columella has left us twelve books upon rural matters. Varro's treatise will ever be esteemed.—Many other Greek and Latin authors might be produced; but these will be sufficient to show, that Agriculture has ever been attended to by the wise Philosopher and the good Citizen.

The celebrated Sully calls Agriculture one of the breasts from which the state must draw its nourishment That great man could not poſsibly have given us a more happy simile. Instructing by precepts, and stimulating by rewards, he prevailed upon his countrymen to cultivate the art; but their industry was of short duration. The public troubles soon put an end to Arts, Agriculture, and Commerce. Colbert entertained a different notion of policy. Esteeming Manufactures and Commerce as the sinews of the state, he gave all poſsible encouragement to the Artizan and the Merchant,—but forgot that the Manufacturer must eat his bread at a moderate price. The Farmer being discouraged, the neceſsaries of life became dear; the public granaries were ill stored;—manufactures languished;—commerce dropped;—a numerous army soon consumed the scanty harvest;—and, in a short time, Industry fell a sacrifice to the ill-judged policy of the Minister.

From that period to the present, the French nation have constantly been availing themselves of their mistake. Under the genial influence of the king, Societies are erected in every Province. Men of the first distinction do not disdain the cultivation of their own lands. M. de Chateauvieux and Duhamel are the greatest ornaments of their country. Let us imitate the virtues of that fashionable nation; and as we have often vanquished them in the field of battle, let us put our hands to the plough, and overcome them in the field of industry. Such pursuits have graced the public life of ancient heroes. May they be recorded in the Annals of a British King.

ESSAY I.

On the Nouriſhment of Vegetables.

THE art of Huſbandry boaſts an origin coëval with the human race. Its age, however, ſeems to have contributed but little towards its advancement, being at preſent extended but a few degrees beyond its primitive inſtitution.

Until the Philoſopher condeſcends to direct the plough, Huſbandry muſt remain in a torpid ſtate. It is the peculiar happineſs of this age, that men of a liberal education begin to cultivate this art with attention. We cannot ſay too much in praiſe of the reſpective ſocieties lately eſtabliſhed in this iſland, and in France, for the improvement of Agriculture. They have raiſed a noble ſpirit of emulation among our country gentlemen and ſenſible farmers. Each ſeems envious of contributing ſomething towards the general ſtock of knowledge.—Such a pleaſing intercourſe cannot fail of ſpreading the improvements in Agriculture over the moſt diſtant parts of this iſland.

I take upon me to ſay, that, to be a good huſbandman, it is neceſſary to be a good chemiſt. Chemiſtry will teach him the beſt way to prepare nouriſhment for his reſpective crops, and, in the moſt wonderful manner, will expoſe the hidden things of nature to his view. The principles of Agriculture depend greatly upon chemiſtry: and without principles, what is art, and what is ſcience?

It is alſo neceſſary for the huſbandman to be a good mechanic, in order to be a judge of the inſtruments employed in dividing and looſening the ſoil; an operation of the greateſt uſe to the farmer.

The ingenious Dr. Home has opened to our view a noble field for improvement. His reaſoning is juſt and concluſive; but it were to be wiſhed that his experiments had been conducted upon a larger ſcale. However, contracted as they are, they will be found of great uſe to whoever intends to purſue the ſtudy of Agriculture upon rational principles.

As I intend the nouriſhment of plants to be the ſubject of this Eſſay, it will be proper to obſerve, that I have been directed in my reſearches by a ſtrict attention to the analogy that ſubſiſts between animals and vegetables. We know that neither of them can ſubſiſt long without air and nouriſhment. Directed by inſtinct, the animal ſeeks its own proper food; but the vegetable, not being poſſeſſed of the power of motion, muſt be ſatisfied with the nouriſhment that we give it.

To direct this upon rational principles, is the buſineſs of the philoſopher. The practical farmer will ſuffer himſelf to be inſtructed, as ſoon as he perceives the practice correſpond with the theory laid down to him. Let us expect no more from him. Men of a limited education commit great errors when they attempt to reaſon upon ſcience. In huſbandry, effects are conſtantly applied to improper cauſes. Hence proceed the errors of our common farmers. To overcome theſe is the peculiar province of the Philoſopher; who, in his turn, muſt ſupport his reaſoning by facts and experiments.

I lay it down as a fundamental maxim, that all plants receive their principal nouriſhment from oily and mucilaginous particles incorporated with water, by means of an alkaline falt or abforbent earth. Till oil is made mifcible, it is unable to enter the radical vefsels of vegetables; and, on that account, Providence has bountifully supplied all natural soils with chalky or other absorbent particles. I say natural soils, for those which have been assisted by art are full of materials for that purpose; such as lime, marl, soap-ashes, and the volatile alkaline salt of putrid dunghills.

It may be asked, whence do natural soils receive their oily particles? I answer, the air supplies them. During the summer months, the atmosphere is full of putrid exhalations arising from the steam of dunghills, the perspiration of animals and smoak. Every shower brings down these putrescent particles for the nourishment of plants. Of these, some fall into the sea, where they probably serve for the nourishment of fuci, and other submarine plants. They are, however, but seemingly lost, as the fish taken from the sea, and the weeds thrown upon the beach, restore them again under a different form. Thus Providence, with the most consummate wisdom, keeps up the necefsary rotation of things, difsolution and combination following each other in endlefs succefsion.

When the putrescent particles that are suspended in the atmosphere, happen to fall upon a very sandy soil, the solar heat exhales the most of them. Hence an additional reason for covering our light soils with herbage during the summer months.

On the contrary, when these particles fall upon stiff land, or such as have been marled or limed, an intimate union is produced, too strong for the solar heat to exhale.

It is observed, that lime mechanically binds a hot sandy soil. We now see that it also fertilizes it; but the farmer must not presume too much upon that quality.

The ingenious Mr. Tull, and others, contend that earth is the food of plants. If so, all soils equally tilled would prove equally prolific. The increased fertility of a well-pulverised soil, induced him to imagine that the plough could so minutely divide the particles of earth, as to fit them for entering into the roots of plants.

An open soil, if not too light in its own nature, will always produce plentiful crops. It readily receives the air, rains, and dews into its bosom, and at the same time gives the roots of plants a free pafsage in quest of food. This is the true reason why land well tilled is so remarkably fruitful.

Water is thought, by some, to be the food of vegetables, when in reality it is only the vehicle of nourishment.—Water is an heterogeneous fluid, and is no where to be found pure. It always contains a solution of animal or vegetable substances. These constitute the nourishment of plants, and the element in which they are minutely suspended, acts only as a vehicle, in guiding them through the fine vefsels of the vegetable body.

The hyacinth, and other bulbous roots, are known to perfect their flowers in pure water. Hence superficial observers have drawn an argument in favour of water being the food of vegetables. But the truth is, the roots, stem, and flowers of such plants are nourished by the mucilaginous juices of the bulb, diluted by the surrounding water. This mucilage is just sufficient to perfect the flower—and no more. Such a bulb neither forms seeds, nor sends forth off-sets. At the end of the season, it appears weak, shrivelled, and exhausted, and is rendered unfit to produce flowers the succeeding year. A root of the same kind, that has been fed by the oily and mucilaginous juices of the earth, efsentially differs in every particular. It has a plump appearance, is full of mucilage—with off-sets upon its sides.

All rich soils, in a state of nature, are thought to contain oil and mucilage; and in those lands which have been under the plough for some years, they are found in proportion to the quantity of putrid dung that has been laid upon them, making an allowance for the crops they have sustained.

To set this matter in a clearer light, let us attend to the effects of manures of an oily nature, and we shall soon be satisfied that oil, however modified and distinguished, is one of the chief things concerned in vegetation.

Rape-dust, when laid upon land, is a speedy and certain manure, though an expensive one, and will generally answer best on a limestone land, or where the soil has been moderately limed.

This species of manure is much esteemed by the farmer. It contains the food of plants ready prepared; but as it is not capable of loosening the soil by any fermetation, the lands upon which it is laid ought to be in excellent tilth. At present, that useful article of husbandry is much diminished in goodneſs, owing to the improved methods of extracting the oil from the rape. Heat and preſsure are employed in a double degree, and every other method is used to the prejudice of the farmer. Some persons, however, are of opinion, that the severe extraction of the oil does not materially injure the rape-dust.

Farmers that live in the neighbourhood of large towns use abundance of soot It is an oily manure, but different from the former, containing alkaline salt in its own nature, calculated as well for opening the soil, as for rendering the oily parts miscible with water.

It is observed that the dung of pigeons is a rich and hasty manure. These animals feed chiefly upon grains and oily seeds; it must therefore be expected that their dung should contain a large proportion of oil.

The dung of stable-kept horses is also a strong manure, and should not be used until it has undergone the *putrid ferment*, in order to mix and afsimilate its oily, watry, and saline parts. Beans, oats, and hay, contain much oil. The dung of horses, that are kept upon green herbage, is of a weaker kind, containing much lefs oil. Swine's dung is of a saponaceous and oily nature, and perhaps is the richest of the animal manures. When made into a compost and applied with judgment, it is excellent both for arable and grafs lands. The dung of stall-fed oxen, especially if oil-cake make part of their food, is of a rich quality, and greatly preferable to that of cows and oxen supported by grafs only. A farmer, when he purchases dung, should attend to all the circumstances under which it is produced. One load of dung from a hunting stable, where much corn is used, is worth two loads produced by hay and green provender.

The dung of ruminant animals, as cows and sheep, is preferable to that of horses at grafs, owing to the quantity of animal juices mixed with their food in chewing. And here I beg leave to remark in general, that the fatter the animal, *cæteris paribus*, the richer the dung.

Human ordure is full of oil and a volatile alkaline salt. By itself, it is too strong a manure for any land; it should therefore be made into a compost before it is used. The dung of carnivorous animals is plentifully stored with oil. Animals that feed upon seeds and grains come next, and after them follow those which subsist upon grafs only.

To suit these different manures to their proper soils, requires the greatest judgment of the farmer; as what may be proper for one soil, may be highly detrimental to another.

In order to strengthen my argument in favour of oil (phlogiston) being the principal food of plants, I must beg leave to observe, that all vegetables, whose seeds are of an oily nature, are found to be remarkable impoverishers of the soil, as hemp, rape, and flax; for which reason, the best manures for lands worn out by these crops, are such as have a good deal of oil in their composition; but then they must be laid on with lime, chalk, marl, or soap ashes, so as to render the oily particles miscible with water.

The Book of Nature may be displayed, to show that oily particles constitute the nourishment of plants in their embryo state; and, by a fair inference, we may suppose that something of the same nature is continued to them as they advance in growth. The oily seeds, as rape, hemp, line, and turnip, consist of two lobes, which, when spread upon the surface, form the seminal leaves. In them the whole oil of the seed is contained. The moisture of the atmosphere penetrates the cuticle of the leaves, and, mixing with the oil, constitutes an emulsion for the nourishment of the plant. The sweetneſs of this balmy fluid invites the fly, against which no sufficient remedy has, as yet, been discovered. The oleaginous liquor being consumed, the seminal leaves decay, having performed the office of a mother to her tender infant. To persons unacquainted with the analogy between plants and animals, this reflection will appear strange. Nothing, however, is more demonstrable.

Most of the leguminous and farinaceous plants keep their placenta, or seminal leaves, within the earth; in which situation they supply the tender germ with oily nutriment, until its roots are grown sufficiently strong to penetrate the soil. The curious reader will find this subject treated of at large in the third Eſsay.

It is usual to talk of the salts of the earth, but chemistry has not been able to discover any salts in land which has not been manured; though it is said that oil may be readily obtained from every soil, the very sandy ones excepted.

Marl, though a rich manure, has no salts. It is thought, by some, to contain a small portion of oleaginous matter, and an absorbent earth, of a nature similar to limestone, with a large quantity of clay intermixed.

Lime, mixed with clay, comes nearest to the nature of marl of any factitious body that we know of, and may be used as such, where it can be had without much expense. By increasing the quantity of clay, it will make an excellent compost for a light sandy soil; but to make the ground fertile, woollen rags, rotten dung, currier's shavings, or any oily manure, should be incorporated with it some time before it is laid on.

It is the opinion of some, that lime enriches the land it is laid upon, by means of supplying a salt fit for the nourishment of plants; but by all the experiments that have been made upon lime, it is found to contain no kind of salt. Its operation, therefore, should be considered in a different light. By the fermentation that it induces, the earth opened and divided, and, by its absorbent and alkaline quality, it unites the oily and watery parts of the soil. It also seems to have the property of collecting the acid of the air, forming with it a combination of great use in vegetation.

From viewing lime in this light, it is probable that it tends to rob the soil of its oily particles, and in time will render it barren, unlefs we take care to support it with rotten dung, or other manures of an oily nature.

As light sandy soils contain but a small portion of oleaginous particles, we should be extremely cautious not to overdo them with lime, unlefs we can at the same time afsist them liberally with rotten dung, shavings of leather, woollen rags, shavings of horn, and other manures of an animal kind. Its great excellence, however, upon a sandy soil, is by mechanically binding the loose particles, and thereby preventing the liquid parts of the manure from escaping out of the reach of the radical fibres of the plants.

Upon clay the effect of lime is different; for by means of the gentle fermentation that it produces, the unsubdued soil is opened and divided; the manures laid on readily come into contact with every part of it; and the fibres of the plants have full liberty to spread themselves.

It is generally said that lime answers better upon sand than clay. This observation will undoubtedly hold good as long as the farmer continues to lime his clay lands in a scanty manner. Let him treble the quantity, and he will then be convinced that lime is better for clay than sand. It may be justly answered, that the profits will not admit of the expense. I agree. But then it must be understood that it is the application, and not the nature of the lime, that should be called in question. Clay, well limed, will fall in water, and ferment with acids. Its very nature is changed.

Under such agreeable circumstances, the air, rains, and dews are freely admitted, and the soil is enabled to retain the nourishment that each of them brings. In consequence of a fermentation raised in the soil, the fixed air is set at liberty, and in that state of activity it becomes an useful instrument in dividing the tenaceous clay. However, let the farmer, who uses much lime for his clay lands, be instructed to manure them well, otherwise the soil will bake and become too hard to permit the roots of the plants to spread themselves in search of food.

It is the nature of lime to attract oils and diſsolve vegetable bodies. Upon these principles we may account for the wonderful effects of lime in the improvement of black moor-land. Moor-earth consists of diſsolved, and half-diſsolved, vegetable substances. It is full of oil.—Lime diſsolves the one, and assimilates the other.

Such lands, not originally worth sixpence per acre, may be made, by paring, burning, and liming, to produce plentiful crops of turnips, which may be followed with oats, barley, or graſs seeds, according to the inclination of the owner.——These observations, however, are rather foreign to the argument of the present efsay, to which I shall now return.

To the universal principle, oil, (phlogiston) we must add another of great efficacy, though very little understood; I mean the nitrous acid of the air.

That the air does contain the rudiments of nitre, is demonstrable from the manner of making salt-petre in the different parts of the world. The air contains no such salt as perfect nitre; it is a factitious salt, and is made by the nitrous acid falling upon a proper matrix. The makers of nitre form that matrix of the rubbish of old houses, fat earth, and any fixed alkaline salt. The universal acid, as it is called, is attracted by these materials, and forms true nitre, which is rendered pure by means of crystalization, and in that form it is brought to us. In very hot countries, the natural earth forms a matrix for nitre, which makes the operation very short.

It is observed that nitre is most plentifully formed in winter, when the wind is northerly:

hence we may understand the true reason why land is fertilized by being laid up in high ridges during the winter months. The good effects of that operation are wholly attributed to the mechanical action of the frost upon the ground. Light soils as well as the tough ones, may be exposed in high ridges, but with some limitation, in order to imitate the mud walls in Germany, which are found, by experience, to collect considerable quantities of nitre during the winter.

After saying so much in praise of nitre, it will be expected that I should produce some proofs of its efficacy, when used as a manure. I must confeſs that experiments do not give us any such proofs. Perhaps too large a quantity has been used; or rather, it could not be restored to the earth with its particles so minutely divided, as when it remained united with the soil, by means of the chemistry of nature. I shall therefore consider this nitrous acid, or as some call it, the *acidum vagum*, in the light of a vivifying principle, with whose operation we are not yet fully acquainted.

I have already observed, that there subsists a strong analogy between plants and animals.

Oil and water seem to make up the nourishment of both. Earth enters very little into the composition of either. It is observed, that animals take in a great many earthy particles at the mouth, but they are soon discharged by urine and stool. Vegetables take in the smallest portion imaginable of earth; and the reason is, they have no way to discharge it.

It is highly probable, that the radical fibres of plants take up their nourishment from the earth, in the same manner that the lacteal vefsels absorb the nutriment from the intesines; and as the oily and watery parts of our food are perfectly united into a milky liquor, by means of the spittle, pancreatic juice, and bile, before they enter the lacteals, we have all the reason imaginable to keep up the analogy, and suppose that the oleaginous and watery parts of the soil are also incorporated, previous to their being taken up by the absorbent vefsels of the plant.

To form a perfect judgment of this, we must reflect that every soil, in a state of nature, has in itself a quantity of absorbent earth, sufficient to incorporate its inherent oil and water; but when we load it with fat manures, it becomes efsentially necefsary to bestow upon it, at the same time, something to afsimilate the parts. Lime, soap-ashes, kelp, marl, and all the alkaline substances, perform that office.

In order to render this operation visible to the senses:—Difsolve one drachm of Rufsia potash in two ounces of water; then add two spoonfuls of oil. Shake the mixture, and it will instantly become an uniform mafs of a whitish colour, adapted, as I conceive, to all the purposes of vegetation.

This easy and familiar experiment is a just representation of what happens after the operation of Burn-baking, and consequently may be considered as a confirmation of the hypothesis advanced. Let us attend to the procefs.

The sward being reduced to ashes, a fixed alkaline salt is produced. The moisture of the atmosphere soon reduces that salt into a fluid state, which, mixing with the soil, brings about an union of the oily and watery parts, in the manner demonstrated by the experiment.

When the under stratum sonsists of a rich vegetable mould, the effects of Burn-baking will be lasting. But when the soil happens to be thin and poor, the first crop frequently suffers before it arrives at maturity.

The farmer, therefore, who is at the expense of paring and burning a thin soil, should bestow upon it a portion of rotten dung, or shambles manure, before the ashes are spread, in order to supply the deficiency of oily particles; and he should be very careful not to keep this kind of land too long under the plough.

In consequence of this prudent management, the crop will be supported during its growth, and the land will be preserved in health and vigour.

For such weak lands, it is highly probable that the oil-compost described in the next efsay, will be found the cheapest and most effectual manure.

Hitherto I have considered plants as nourished by their roots. I shall now take a view of them as nourished by their leaves. An attention to this part of the vegetable system is efsentially necefsary to the rational farmer.

Vegetables that have a succulent leaf, such as vetches, pease, beans, and buck-wheat, draw a great part of their nourishment from the air, and on that account impoverish the soil lefs than wheat, oats, barley, or rye, the leaves of which are of a firmer texture.

In this manner the vegetable creation renders the air pure by afsimilating to itself those putrescent particles, which, if not removed, would render the atmosphere unfit for animal respiration. Some modern philosophers have attempted to destroy this opinion, but they must bring stronger proofs than those they have produced, before they can expect to tear from the human breast an idea so full of harmony.

Rape and hemp are oil-bearing plants, and, consequently, impoverishers of the soil; but the former lefs so than the latter, owing to the greater succulency of its leaf.

The leaves of all kinds of grain are succulent for a time; during which period the plants take little from the earth; but as soon as the ear begins to be formed, they lose their softnefs, and diminish in their attractive power.

The radical fibres are then more vigorously employed in extracting the oily particles of the earth, for the nourishment of the seed. Such, I apprehend, is the course of nature.

ESSAY II.

On a rich and cheap Compoſt, &c.

IN the last eſsay I endeavoured to show that oil, made miscible with water, constitutes the chief nourishment of vegetables. A greater number of proofs might have been produed in support of that doctrine; but I flatter myself that those already advanced will be thought sufficient.

Having reason to believe that my theory was founded upon facts and experiments, I was desirous of converting it to public utility. And as I apprehended that a compost might be discovered, upon the principles advanced, which would come cheap to the farmer, and be of easy carriage, I diligently employed myself in prosecuting the inquiry.

In the course of investigation I took care to reason upon proper data; carefully avoiding every degree of partiality to my system.—In philosophy nothing is so delusive as prejudice.

After making various trials, I at last discovered what I so ardently sought after; but as I have not the vanity to think my experiments sufficiently conclusive, I embrace this opportunity to request the afsistance of the practical farmer, in order that the merits of the invention may be fully determined.

Should my theory concerning the food of plants be found erroneous, the compost, of course, will be disregarded. But, on the contrary, should it be agreed to, that oil, under certain modifications, made miscible with water, constitutes the chief nourishment of vegetables, then the invention will probably become a subject for future experiment.

Though theory may direct our inquiries, yet experience must at last determine our opinions, for which reason I propose to enlarge my experiments; and as I have no other view but the investigation of truth, I shall lay them faithfully before the public, whether they prove succefsful or not.

We know that a number of experiments, made by different persons, and in different places, are efsentially necefsary towards establishing the truth of any received opinion in Agriculture. How much more necefsary is it to request the afsistance of the practical farmer, in determining the merits of a new invention? for such I esteem the compost I here communicate.

Virgil, indeed, has recommended the lees of oil as a manure, and the ingenious Dr. Home has mentioned olive oil; but neither of them reflected upon the absolute necefsity of rendering the oil miscible with water, by means of an alkaline salt.

I judge it unnecefsary to repeat what I have already advanced upon the food of plants. I shall therefore refer the reader to the fi[illegible] Efsay, as it contains the greatest part of the reasoning upon which the following compost is founded.

To make Oil-Compost.

	l.	*s.*	*d.*
Take North-American pot-ash 12 lb.	0	4	0
Break the salt into small pieces, and put it into a convenient vefsel with four gallons of water. Let the mixture stand forty-eight hours, then add coarse train-oil, 14 gallons	0	14	0
	£0	18	0

In a few days the salt will be difsolved, and the mixture, upon stirring, will become nearly uniform.

Take fourteen bushels of sand, or twenty of dry mould. Upon these, pour the above liquid ingredients. Turn this composition frequently over, after adding to it as much fresh horse dung as will bring on heat and fermentation; in six months it will be fit for use.

I apprehend that the above quantity will be found sufficient for an acre: my trials, however, do not give me sufficient authority to determine upon this point.

For the convenience of carriage, I have directed no more earth to be used than will effectually take up the liquid ingredients. But if the farmer chooses to mix up the compost with the mould of his field, I would advise him to use a larger portion of earth, as he will thereby be enabled to distribute it with more regularity upon the surface. I have not yet had any extensive trial of its efficacy upon pasture and meadow grounds: but I presume that whatever will nourish corn, will also feed the roots of grafs. When used upon such lands, it should be put on during a rainy season, as all top-drefsings are injured by the solar heat.

All kinds of cattle must be kept off the lands for some time, as they will bite the grafs too close in quest of the salt contained in the compost, which I have found to be the case in small trials.

I shall here observe, that the oil-compost is only intended to supply the place of rape-dust, soot, woollen rags, and other expensive hand-drefsings. It is in all respects inferior to rotten dung: where that can be obtained, every kind of manure must give place to it.

At the same time that dung affords nourishment, it opens the pores of the earth. Hand-drefsings, on the contrary, give food to plants, but contribute little towards loosening the soil. This is an useful and practical distinction, and may be applied through all the variety of manures made use of by the farmer.

I presume that the oil-compost resembles the natural food of plants; but I submit that, as well as every thing else, to experience, our unerring guide.

It may be objected, that it has not sufficiently undergone the *putrid ferment*, to attenuate the oily particles. The use of rape-dust, soot, horn shavings, and woollen rags, take off that objection, and at the same time confirm the theory upon which the above compost is founded.

I do not take upon me to direct the experienced farmer in the manner of using this new compost. I would have every person apply it in the way most agreeable to himself. Many things will occur to the practical husbandman, that no reasoning of the philosopher could foresee. By attending to the different ways of using it, we may reap considerable advantages. Improvements may be collected even from the highest degree of mismanagement.

Facts must ever be the foundation of our reasoning. Without them, the philosopher is a kind of *Ignis fatuus*. Instead of unfolding nature, he covers her with a cloud, and endeavours, as it were, to bring old Chaos back again into the world.

Should I presume to instruct the farmer in the management of the compost, I would recommend it to be sown immediately after the grain, and both harrowed in together.

The following experiment, though trifling in its own nature, gave me the first encouragement to prosecute the subject upon a larger scale.—I took four pots, N° 1, 2, 3, 4.

N° 1. contained 12 lb. of barren sand, with 1 oz. of the sand oil-compost.

N° 2.—12 lb. of sand, without any mixture.

N° 3.—12 lb. of sand, with ½ oz. of slaked lime.

N° 4.—12 lb. of sand, with 4 oz. of the sand oil-compost.

In the month of March, I put six grains of wheat into each pot, and during the summer I occasionally watered the plants with filtered water. All the time that the plants were consuming the farina, I could observe but little difference in their appearance. But after one month's growth, I remarked that N° 1. was the best. N° 2. the next. N° 3. the next. N° 4. much the worst.

In August, I made the following observations.

N° 1. had five small ears, which contained a few poor grains.

N° 2. had three small ears, which scarce deserved the name of ears, containing a few grains, much inferior in goodneſs to the former.

N° 3. had no ears. Only I observed two very small ones within their respective sheaths, which, for want of vegetable strength, never made their appearance.

N° 4. had no ears; the stalks appearing stunted in their growth.

I removed the plants from their pots, and took a view of the roots of each.

N° 1. The roots tolerably large, and well spread.

N° 2. The roots not so large.

N° 3. The roots very short and small.

N° 4. The roots much the shortest, with the appearance of being ricketty.

Upon this experiment I remark:

1. That the oil-compost may be considered as a vegetable food: but that, when used too liberally, the alkaline salt will burn up the roots of the plant, and hinder vegetation. For which reason I would recommend the compost to be exposed to the influence of the air, for some months, before it is laid on.

2. That lime contains no vegetable food, and is, in its own nature, an enemy to vegetation. It is, however, of excellent use in afsisting vegetation, in the manner described in the first Efsay.

My experiments teach me, that all kinds of soils may be benefitted by this manure. The limestone, gravelly, sandy, and chalky soils seem to require it most. The rich loams and good clays have nourishment within themselves, and stand more in need of the plough than the dunghill.

It is observed by farmers, that rape-dust seldom succeeds with spring-corn, unlefs plentiful rains fall within a few weeks after sowing. I have more than once made the same observation upon the oil-compost, which induces me to recommend it for winter crops only. From the unctuousnefs of its nature, it is more than probable, that it should lie exposed for a long time to the influence of the weather, which benefit it is deprived of when used for barley, and such crops as are sown late in the spring. I am confirmed in this idea, from repeated experiments made with the compost upon turnips, which generally proved unsuccefsful. But at the same time I invariably found that those parts of the field on which the compost had been spread, produced the best crops of grain the following year. From this slow manner of giving its virtues, it seems to be an improper drefsing for all plants that have a quick vegetation.

Agreeably to the theory advanced in the first Efsay, I presume that all lands, which have been exhausted by frequent crops, are robbed of their oily particles, and consequently have become barren. The oil-compost, as it plentifully restores particles similar to those that are carried off, has a fair appearance of proving an excellent restorative. To lands under such circumstances, lime alone is the worst manure that can be applied.

This last observation naturally leads me to wish for a general history of manures, upon sound and rational principles. I cannot help regarding that necefsary part of husbandry, as a subject but imperfectly understood. Whoever succeeds in that difficult task, will prove himself a real friend to mankind. Without it, agriculture must remain a vague and uncertain study.

ESSAY III.

On Vegetation, and the Analogy between Plants and Animals.

VEGETABLES are placed in a middle degree between animals and minerals. They are superior to minerals, in having organized parts; but inferior to animals, in being destitute of sensation.

As they are fixed to a place, they have few offices to perform. An increase of body and maturation of their seed, seems all that is required of them. For these purposes Providence has wisely bestowed upon them organs of a wonderful mechanism. The anatomical investigation of these organs, is the only rational method of arriving at any certainty concerning the laws of the vegetable Economy. Upon this subject Dr. Hales judiciously observes, " that as the growth and preservation " of vegetable life is promoted and maintained " as in animals, by the very plentiful and re- " gular motion of their fluids, which are the

" vehicles ordained by nature to carry nutri-
" ment to every part, it is therefore reasonable
" to hope that in them also, by the same
" method of inquiry, considerable discoveries
" may in time be made, there being, in many
" respects, a great analogy between plants
" and animals."

The seed of a plant, after it has dropt from the ovarium, may be considered as an impregnated ovum, within which the embryo plant is securely lodged. In a few days after it has been committed to the earth, we may discern the rudiments of the future plant.—Every part appears to exist in miniature. The nutritive juices of the soil insinuate themselves between the original particles of the plant, and bring about an extension of its parts. This is what is called the growth of the vegetable body.

With regard to this increase by addition and extension, there seems to be a great analogy between the animal and vegetable kingdoms. In a former efsay I endeavoured to prove, that oily particles constitute the chief nourishment of plants and animals; and as I apprehend that much depends upon a proper investigation of the subject, I shall occasionally introduce some other proofs in support of my opinion.

Every one knows that animals, instead of being strengthened, are enfeebled by a supply of improper nourishment. It is the same thing with regard to vegetables; but with this difference, that animals refuse whatever is improper; while vegetables, from their paſsive nature, must be content with what we give them.

When a farmer once becomes acquainted with the nature of the food of plants, he will find himself rationally instructed in the manner of compounding dunghills, and the application of the various manures made use of in husbandry. At present, no part of rural Economy is so imperfectly understood.—But to return.

The impregnated ovum of every animal, after it has paſsed down the Fallopian tube, and fixed itself to the bottom of the uterus, is found to contain the tender embryo within two membranes called Chorion and Amnion. In this situation the embryo could not long subsist without a supply of nourishment.—

Nature has therefore bestowed upon it a placenta and umbilical chord, through which the blood and juices of the mother are transmitted, for its preservation and increase.

Seeds are disposed by Providence, nearly in the same manner. They have two coverings, answering to the Chorion and Amnion, and two lobes which perform the office of the placenta. These lobes constitute the body of the seed, and, in the farinaceous kinds, they are the flour of the grain. Innumerable small vefsels run through the substance of the lobes, which, uniting as they approach the seminal plant, form a small chord to be inserted into the body of the germ. Through it the nutriment supplied by the placenta, or lobes, is conveyed for the preservation and increase of the embryo plant.

In order that I may be clearly understood, it will be necefsary to observe, that the lobes of farinaceous grains are fixed in the earth.—They are therefore improperly termed seminal leaves, being rather the placenta, or cotyledons of the plant. On the contrary, vegetables that have an oily seed, as rape, hemp, line, and turnip, carry their lobes upward, and

INSERT FOLDOUT HERE

spread them upon the surface, in the form of broad leaves. These, though they perform the office of a placenta, are properly seminal leaves;—and to this distinction I shall adhere.

Plate 1. Fig. i. represents the body, or placenta of a bean, with its germ, radicle, umbilical chord, and ramifications.—*a*. The germ. *b*. The body, or plàcenta, with the umbilical chord and ramifications.—*c*. The radicle.

Fig. 3. represents the placenta, or seed-leaves, of a turnip, with its radicle and germ. *a*. The germ.—*b*. The placenta, or seed-leaves. *c*. The radicle.

Fig. 4. represents the germ of a grain of wheat, with its root and capsule, containing the milky juice for the nourishment of the tender plant.—*a*. The origin of the crown.—*b*. The pipe of communication between the first roots and the crown, at this time covered by a membranous sheath.—*c*. The grain with its seminal root. At this season the grain is filled with a milky juice, for the support of the plant, during what may be called its infant state.

To illustrate the subject of vegetation, let us take a view of what happens to a bean, after it has been committed to the earth.

In a few days, sooner or later, according to the temperature of the weather and the disposition of the soil, the external coverings open at one end, and disclose to the naked eye part of the placenta, or body of the grain. This substance consists of two lobes, between which the seminal plant is securely lodged. Soon after the opening of the membranes, a sharp-pointed body appears. This is the root. By a kind of principle, which seems to carry with it some appearance of instinct, it seeks a pafsage downwards, and fixes itself into the soil. At this period the root is a smooth and polished body, and perhaps has but little power to absorb any thing from the earth, for the nourishment of the germ.

The two lobes now begin to separate, and the germ, with its leaves, may plainly be discovered. As the germ increases in size, the lobes are further separated, and the tender leaves being closely joined, push themselves forward in the form of a wedge.

These leaves take a contrary direction to the root. Influenced by the same miraculous instinct, if I may be allowed the exprefsion, they seek a pafsage upward, which having obtained, they lay aside their wedge-like form, and spread themselves in a horizontal direction, as being the best adapted for receiving the rains and dews.

The radicle, every hour increasing in size and vigour, pushes itself deeper into the earth, from which it now draws some nutritive particles. At the same time the leaves of the germ, being of a succulent nature, afsist the plant, by attracting from the atmosphere such particles as their tender vefsels are fit to convey. These particles, however, are of a watery kind, and have not, in their own nature, a sufficiency of nutriment for the increasing plant.

Vegetables and animals, during their tender states, require a large share of balmy nourishment. As soon as an animal is brought into life, the milk of its mother is supplied in a liberal stream, while the tender germ seems only to have the crude and watery juices of the earth for its support. In that, however, we are deceived. The Author of Nature, with equal eye, watches over the infancy of all his works. The animal enjoys the milky humour of its parent. The vegetable lives upon a similar fluid, though differently supplied.—For its use the farinaceous lobes are melted down into a milky juice, which, as long as it lasts, is conveyed to the tender plant by means of innumerable small vefsels, which are spread through the substance of the lobes. These vefsels, uniting into one common trunk, enter the body of the germ, and perform the office of an umbilical chord. Without this supply of balmy liquor, the plant must inevitably have perished, its root being then too small to absorb a sufficiency of food, and its body too weak to afsimilate it into nourishment.—See Plate 1. Fig. 1. and 4.

Turnips, and all the tribe of Brafsicas, in opposition to the leguminous and farinaceous plants, spread their seminal leaves upon the surface. These leaves contain all the oil of the seed, which, when diluted by the moisture of the atmosphere, forms an emulsion of the most nourishing quality. How similar is this juice to the milk of animals! On account of its sweetnefs, the seminal leaves are greedily devoured by the fly.

This demonstrably proves that oil constitutes the nourishment of plants in their tender state; and, by a fair inference, we may suppose that it also nourishes them as they advance in growth.

A grain of wheat, as soon as the germ has made its appearance, shows the milky liquor to the naked eye; but the umbilical chord, with its ramifications, as far as I know, can only be discovered by analogy. As the plant increases in size, the balmy juice diminishes, till at last it is quite exhausted. The umbilical chord then dries up, and the external covering of the grain appears connected to the root in the form of a shrivelled bag.—See Plate 1. Fig. 2. *c*.

Here is no mortality. From the moment that the seed is lodged in its parent earth, the vegetative soul begins its operations, and, in one continued miracle, proves the wisdom and bounty of an almighty Providence.

It is worthy of observation, that farinaceous vegetables and oviparous animals are nourished, in their tender states, nearly in the same manner.

We have already seen that the embryo plant is supported by the farina melted down into a milky liquor, and conveyed into its body by means of an umbilical chord, at a time when the radicle was unable to supply a sufficiency of nutriment.

An oviparous animal, from the time that it is brought into light, seems to receive all its nourishment from without. This, however, is only an appearance. The yolk of the egg, remaining entire during incubation, is received into the body of the animal, and, in a manner similar to the paſsage of the milky juice of the vegetable, is slowly conveyed into the veſsels of the tender chick.—Thus a sweet nourishment is prepared at a time when neither the industry of the animal, nor the attention of its mother, could have procured a sufficient supply.

How beautiful are the general laws of Providence! The more we explore them, the more we have cause for wonder and astonishment. Every thing is wisely disposed; nothing is fortuitous: all is order, regularity, and wisdom.

ESSAY IV.

On Steeps.

THE steeping of seeds in prolific liquors is not of modern invention. The Romans, who were good husbandmen, have left us several receipts for the steeping of grain, in order to increase the powers of vegetation.—In England, France, Italy, and in all countries where agriculture has been attended to, we see a variety of liquors recommended for the same purpose. Good nourishment has ever been observed to add strength and vigour to all vegetables. Hence it was natural to suppose that, by filling the vefsels of the grain with nourishing liquors, the germ, with its roots, would be invigorated. How far this reasoning is founded upon just principles, remains to be examined.

For my part, I am not an advocate for steeps. All my experiments demonstrate that they have no inherent virtue. I have more than once sown the same seed, steeped and unsteeped, and though all other circumstances were minutely alike, yet I never could observe the least difference in the growth of the crop. I confefs that when the light seeds are skimmed off, as in the operation of brining, the crop will be improved, and diseases prevented: but these advantages proceed from the goodnefs of the grain sown, and not from any prolific virtue of the steep.

I am happy in not being singular in my objection to steeps. Many rational farmers have been induced to quit their prejudices, and are now convinced, from their own trials, that there is no dependence upon prolific liquors, though ever so well recommended.— Some people have been hardy enough to persuade themselves, that the tillering of wheat may be so much increased by invigorating the grain, that only one half of the seed will be required.

Duhamel, one of the most accurate of the experimental husbandmen, and a most excellent philosopher, speaks, in the strongest terms, against the practice of steeping, so far as it supposes an impregnation of vegetative particles. I shall not here repeat his experiments. I shall only observe, that they are such as any farmer may make. They are plain and conclusive.

Good seed, when sown upon land in excellent tilth, will always produce a plentiful crop. The best of grain impregnated to the full with the most approved steep, and sown upon land indifferently prepared, will for ever balk the hopes of the farmer.

I do not presume to condemn the practice in positive terms, because my experiments are against it. Other experiments may be opposed to mine. I shall therefore rest the whole upon a description of what happens to the grain after it has been committed to the earth, and hope that I shall be able to explain myself with sufficient perspicuity. The subject is curious, and the discufsion of it not very difficult.

A grain of wheat contains, within two capsules, a considerable share of flour, which, when melted down into a liquor by the watery juices of the earth, constitutes the nourishment of the tender plant, until its roots are grown sufficiently large to absorb their own food. Here is evidently a storehouse of nutriment. And from that idea it is plain that the plumpest grains are the most eligible for seed.

Some have imagined that poor grains may be so impregnated, as to make them equal in vegetative force to the largest. I have more than once made the experiment, and am convinced that plump seeds, of the same heap, are superior in goodnefs to the small ones, though ever so carefully macerated. The farina being the food of the embryo plant, it follows that the vegetative powers will be increased in proportion to its quantity. This observation applies to those farmers who send their large and plump beans to market, and preserve the small ones for seed.

I have sprouted all kinds of grain in a variety of steeps, and can afsure the farmer, that the radicle and germ never appeared so vigorous and healthy, as when sprouted by elementary water: an argument that the seed requires no afsistance. The same steep, when applied in quantity to the soil, will un-undoubtedly invigorate the roots, and nourish the plant; but in that case it operates in common with other manures, and loses the idea of a steep.

As nitre, sea-salt, and dung, are generally added to the steeps, I have constantly observed that their application rendered the radicle and germ yellow and sickly; a plain proof that they were unnaturally used at that season. Did the farina need any additional particles, it might be supposed, that broth made of the flesh of animals would be the most agreeable. To be satisfied of that, I sprouted some grains in beef broth, and an equal number in simple water. The result was, that the radicle and germ produced by the broth, were weaker and lefs healthy than the others sprouted by the pure element.—The seeds were afterwards sown, but I could not perceive any difference in the ears when arrived at maturity.

From these, and many other reasons, I am induced to think that all invigorating steeps are only additional troubles and expense to the farmer. Correct experiments do not seem to prove their efficacy.

It is customary for the farmer to brine his seed-wheat and afterwards to lime it, with a view to prevent the smut; conceiving that the brine and lime, by a kind of corrosion, will act upon such seeds as are infected with smut. But others are of opinion, that the brining only serves to enable the farmer to skim off the weak grains; a circumstance that, with a certainty, will improve the crop.—And here I beg leave to observe, that I confine my idea of steeps to the supposed power of giving to seeds a vegetative force by means of certain *prolific* liquors which are thought to invigorate the germ, by mixing with the farinaceous part of the seed.

To sum up all. I shall venture to say, that plump seed, clear of weeds, and land well prepared to receive it, will seldom disappoint the expectations of the farmer: and upon these he should rely for the goodnefs of his crop.

ESSAY V.

On the Roots of Wheat.

It is not sufficient for the farmer to be acquainted with the nature of the different soils. He should also know the shape of the roots of such plants as are used in field-husbandry. The soil and roots are so intimately connected, that the knowledge of both becomes efsential.

I have selected the roots of wheat for the subject of the present efsay. That grain, being the most valuable, demands our greatest attention.

Wheat has two sets of roots. The first comes immediately from the grain; the other shoots from the crown some time after.—I shall distinguish them by *seminal* and *coronal* roots.

Plants, according to their species, observe a regular uniformity in the manner of spreading their roots; for which reason the same grain cannot be continued long upon the same soil. It is not that each takes from the earth such particles as are congenial. The food of all plants is the same; only some require more, some lefs. Some take it near the surface, others seek it deeper.——This opens to our view a noble field of instruction. A careful inspection of a healthy root will at once demonstrate the bias of nature. An examination of the soil will show how far they will coincide. This is the rational basis of the change of species, so well understood in Norfolk, where tap-rooted plants always follow those that root superficially.

Wheat being subject to the severity of winter, its roots are wonderfully disposed to withstand the inclemency of the season.—A view of their shape will direct us in the manner of sowing that grain to the most advantage; and at the same time enable us to account for some of the phænomena observable in the growth of it.

I have observed that wheat has a double root. The first, or *seminal* root, is pushed out at the same time with the germ, which, together with the farina, nourishes the plant until it has formed its crown. Plate 1. Fig. 4. *a*. The origin of the crown.—*b*. The pipe of communication, at this time covered with a membranous sheath.—*c*. The grain with its *seminal* root.

In the spring, when the crown has become sufficiently large, it detaches a number of strong fibres, which push themselves obliquely downwards. These are the *coronal* roots.—A small pipe preserves the communication between them and the *seminal* roots. It makes an efsential part of the plant, and is observed to be longer or shorter, according to the depth that the seed has been buried. It is remarkable, however, that the crown is always formed just within the surface. Its place is the same, whether the grain has been sown deep or superficial. I believe I do not err when I call this *vegetable instinct* As the increase and fructification of the plant depends upon the vigorous absorption of the *coronal* roots, it is no wonder that they should fix themselves so near the surface, where the soil is always the richest. From an attention to this circumstance, we are led to explain the operation of top-drefsings.

In the northern counties wheat is generally sown late. When the frost comes, the *coronal* roots, being young, are frequently chilled.—This inconvenience, however, may easily be prevented by sowing more early, and burying the seed deeper. The *seminal* roots being out of the reach of the frost, will then be enabled to send up nourishment to the crown, by means of the pipe of communication.

Plate 1. Fig. 2. represents a plant of wheat sown at a proper depth.—*a*. The crown with its roots.—*b*. The pipe of communication.—*c*. The *seminal* roots, with the capsule of the grain.

Plate 2. Fig. 5. shows a plant of wheat sown superficial.—*a*. The crown and roots.—*b*. The pipe of communication.—*c*. The *seminal* roots, and capsule of the grain.

Hence it is obvious that wheat, sown superficially, must be exposed to the severity of the frost from the shortneſs of the pipe of communication. The plant, in that situation, has no benefit from its double root. On the contrary, when the grain has been properly covered, the *seminal* and *coronal* roots are kept at a reasonable distance.—The crown, being well nourished during the winter, sends up numerous stalks in the spring.—On the tillering of the corn, the goodneſs of the crop principally depends. A field of wheat dibled, or sown in equi-distant rows by the drill-plough, always makes a better appearance than one sown by the harrows. In the one, the pipe of communication is regularly of the same length; but in the other it is irregular; being either too long or too short.

From these anatomical facts, many practical advantages may be reaped. I shall not here relate them. They will readily occur to the discerning husbandman.

ESSAY VI.

On Vegetation and the Motion of the Sap.

ANIMAL bodies, from the nature of their structure, are liable to diseases. Vegetables, being lefs complicated, have fewer maladies. The laws of the animal economy are discovered by anatomical inspection. The vegetable economy has the same foundation.

Malpighi and Grew, unknown to each other, undertook the anatomy of plants nearly about the same time. The engravings that they have left us, are lasting monuments of their industry and attention. Many things, however, have been found out since their days. Many things remain yet to be discovered.

The general and obvious parts of a plant are five. The root, the stem, the branches, the leaves, the flower. The component parts of these divisions are simple in comparison to the animal body. The offices of a vegetable, being only increase and fructification, there was no necefsity for a complicated structure.

A good microscope discovers the constituent parts of a plant to be; 1. A very thin outer rind. 2. An inner rind, much thicker than the former. 3. A blea, of a spungy texture. 4. A vascular series. 5. A fleshy substance, which answers to the wood of a tree, or shrub. 6. Pyramidal vefsels contained within the flesh. And, 7. A pith.

Whatever part of the plant we examine, we observe these, and no more. The root, its ascending stalk, and descending fibre, are one and not three substances. This reduces the entire vegetable to one body, and what appears in the flower to be many parts, are only the extremities of the seven above-mentioned. The cup terminates the outer bark. The inner rind ends in the outer petals. The blea forms the inner petals. The vascular series ends in the nectaria. The flesh makes the filaments. The pyramidal vefsels form the receptacle. The pith furnishes the seeds and their capsules.

Words not being able to convey an adequate idea of these parts, I must beg leave to refer the reader to the excellent engravings of Dr. Hill, as published in his Vegetable System.

As I apprehend that his researches into the vegetable creation are more minute than those of his predecefsors, I have followed him in the enumeration of the constituent parts of a plant. He has justly recommended the black hellebore as the properest subject for difsection.—It is a perennial plant of a firm texture, and not too complex, consisting only of a root, radical leaves, and a flower stem.

A careful maceration of the parts, a good microscope, and a most delicate touch, are efsentially necefsary towards investigating the structure of vegetable bodies.

Trees, shrubs, and herbs are organized in the same manner; but the colour and thicknefs of their component parts are different, according to their respective natures.

The outer bark is the first thing that presents itself to our view. It has the appearance of a fine film full of irregular meshes, though in reality it consists of two membranes, with a series of vefsels between them. These take their course upwards, and as they advance towards the cup of the flower inosculate with the small vefsels of the inner bark, into which they pour part of the juices they have received from the earth and the atmosphere. The fine meshes serve the purposes of inhalent or exhalent pores, according to the circumstances of the weather.

The inner bark is much thicker than the outer. It is made up of several flakes laid evenly upon one another, each of which consists of two membranes inclosing a series of veſsels. These communicate freely through the whole substance of the rind, and as they inosculate with the veſsels of the outer bark, so they also communicate with those of the blea.

The blea lies immediately under the inner bark. It is one complete and single substance, uniform in its structure. It is of a considerable thickneſs, and is made up of beds of hexagonal cells. In the angles formed by these cells, we observe the veſsels of the blea. They pour their contents into the cells, which appear to be reservoirs for the water imbibed by the plant.

Underneath the blea, lies the fourth substance called the Vascular Series. Its structure is extremely simple, being a single course of greenish vefsels lodged between two membranes. It terminates in the nectaria. At a certain season of the year, the juices of the vascular series are very mucilaginous. They are particularly so in the holly, and seem to be more elaborated than those of the blea.— Its vefsels have a free communication with the wood and blea.

The favourers of a circulation afsert, that through these vefsels, the returning sap descends; but by the most accurate experiments of Dr. Hales, it appears that the vegetable juices do rise and fall in the same series of vefsels, and consequently have no circulation.

The wood, or fleshy part of a plant, comes next to be examined. In this the life of the vegetable seems to be placed. It is universal in the plant, and is made up of strong fibres. From it all the other parts are produced. It shoots a pith inward, and a rind, blea, and vascular series outward. The filaments in the flower, which are efsential parts in the production of new plants, are continuations of it. And as the seed-vefsels are portions of the pith, so are the petals and nectaria continuations of the rind, blea, and vascular series; all which the plant shoots outward. Through every part of the wood, or flesh, there are vefsels that carry a juice highly elaborated, the greatest part of which has undergone the concoction of the rinds, blea, and vascular series. The woody fibres constitute an order of vefsels, which are named Tracheæ. These are filled with elastic air, and may be discovered, by the eye, in the wood of all trees. The Tracheæ make up an arterial system, and supply the place of the heart in animals. Being filled with air, they become subject to the alternacies of heat and cold.— Their use shall be explained hereafter.

The pyramidal vefsels are spread through all the substance of the flesh, and, as they advance upwards, their ramifications inosculate, so as to prevent any pofsible obstruction of the sap. Their juices, as I have observed, are highly elaborated, having pafsed through all the orders of sap-vefsels. It will here be necefsary to remark, that the sides of these vefsels are constantly in contact with the Tracheæ; so that, from the nature of their situation, they must, at all times, be subject to the vicifsitudes of the weather. The pyramidal veſsels communicate with the pith, which remains to be described.

The pith is to be found in all trees, shrubs, and plants. It occupies the centre, but is not always regularly continued. When examined by a microscope, it has the appearance of a number of vesicles, and is of an uniform structure. It does not appear to be absolutely neceſsary to vegetation, as we often observe elms and other trees, to live and thrive without it.—In trees it is found in the branches, being obliterated in the trunk. The veſsels of the flesh communicate with it. From them it receives a fluid; and probably it is the receptacle of some part of the sap. In extreme dry weather such a store may be neceſsary.

Transverse sections of the ribs of leaves discover it. When minutely traced, it is found to run up to the ovarium, where it forms the seeds and their capsules.

From this survey of the anatomy of a plant, it is evident that there is a correspondence between all its parts. By means of a variety of strainers, different juices are prepared from the same mafs. Matter, considered as matter, has no share in the qualities of bodies. It is from the arrangement of it that we have so many different substances in nature. We may eat the earth, and we may drink the water that moistens it, and yet, from the modification of its parts, it is capable of producing both bread and poison.

We reason improperly, when we say that every plant takes from the earth such particles as are natural to it. A lemon, ingrafted upon an orange stock, is capable of changing the sap of the orange into its own nature, by a different arrangement of the nutritive juices. A mafs of innocent earth can give life and vigour to the bitter aloe, and to the sweet cane; to the cool house-leek, and to the fiery mustard; to the nourishing grains, and to the deadly night-shade.

The fibres of a root are supposed to be simple capillary tubes: but upon a minute inspection, we discover them to consist of the seven component parts of the plant. At their extremities we observe a spungy kind of excrefcence pierced with innumerable small holes. Through these the nutritive juices of the earth are absorbed. When a plant has been pulled up, it will be retarded in its growth, until nature has renewed that spungy nipple.

The bark and leaves of a plant imbibe, at proper seasons, the moisture of the atmosphere. At other times they perspire the superfluous nourishment. This opens to our view an extensive prospect of the vegetable economy.

We have already seen that all the parts of a plant are the same. They only differ in shape. The roots are formed sharp and pointed, to make their pafsage easier through the earth. The leaves are made broad, to catch the moisture of the air with more readinefs. When the root of a tree happens to be elevated, instead of being retained within the earth, it afsumes the appearance of a perfect plant, with leaves and branches. Experiments show us that a young tree may have its branches placed in the earth, and its roots elevated in the air; and in that inverted state it will continue to live and grow.

The air contains, especially during the summer months, all the principles of vegetation, Oil (phlogiston) for the perfect food, water to dilute it, and salts to afsimilate it. These are greedily absorbed by the vefsels of the leaves and bark, and conveyed to the innermost parts of the plant for its growth and fructification. When the air happens to be cold and moist, this absorption takes place. When it is hot and dry, the same vefsels throw off the superfluous moisture by perspiration. In animals, the kidneys and pores of the skin carry off the superfluity. The vegetable not having kidneys perspires more than the animal.—Dr. Hales has demonstrated that this perspiration is considerable. I shall here transcribe his statical experiments upon the sun-flower, for the benefit of those who may not have an opportunity of examining the original.

" July 3, 1724. In order to find out the " quantity imbibed and perspired by the sun- " flower, I took a garden-pot (Plate 1. Fig. 6.) " with a large sunflower, *a*, 3 feet 4½ inches " high, which was purposely planted in it " when young: it was of the large annual " kind.

" I covered the pot with a plate of thin " milled lead, and cemented all the joints fast,

" so as no vapour could paſs, but only air, " through a small glaſs tube, *b*, nine inches " long, which was fixed purposely near the " stem of the plant, to make a free communi- " cation with the outward air, and that " under the leaden plate.

" I cemented also another short glaſs tube, " *c*. into the plate, two inches long and one " inch in diameter. Through this tube I " watered the plant, and then stopped up also " the holes, *d, e*, at the bottom of the pot " with corks.

" I weighed this plant and pot, morning " and evening, for fifteen several days, from " July 3 to August 8, after which I cut off " the plant close to the leaden plate, and then " covered the stump well with cement, and " upon weighing found there perspired through " the unglazed porous pot two ounces every " twelve hours day, which being allowed in " the daily weighing of the plant and pot, " I found the greatest perspiration of twelve " hours, in a very warm dry day, to be one " pound fourteen ounces; the middle rate of " perspiration, one pound four ounces. The " perspiration of a dry warm night, without

" any sensible dew, was about three ounces;
" but when any sensible, though small dew,
" then the perspiration was nothing; and
" when a large dew, or some little rain in the
" night, the plant and pot was increased in
" weight two or three ounces.

" N. B. I used avoirdupois weights.

" I cut off all the leaves of this plant, and
" laid them in five several parcels, according
" to their several sizes, and then measured the
" surface of a leaf of each parcel, by laying
" over it a large lattice made with threads, in
" which the little squares were a quarter of an
" inch each; by numbering of which I had
" the surface of the leaves in square inches,
" which, multiplied by the number of the
" leaves in the corresponding parcels, gave me
" the area of all the leaves; by which means
" I found the surface of the whole plant, above
" ground, to be equal to 5616 square inches,
" or 39 square feet.

" I dug up another sun-flower, nearly of
" the same size, which had eight main roots,
" reaching fifteen inches deep and sideways
" from the stem: it had besides a very thick
" bush of lateral roots, from the eight main

" roots, which extended every way in a " hemisphere, about nine inches from the " stem and main roots.

" In order to get an estimate of the length " of all the roots, I took one of the main " roots, with its laterals, and measured and " weighed them; and then weighed the other " seven roots, with their laterals; by which " means I found the sum of the length of all " the roots to be no lefs than 1448 feet.

" And supposing the periphery of these " roots at a medium, to be 0.131 of an inch, " then their surface will be 2276 square inches, " or 15.8 square feet; that is equal to 0.4 of " surface of the plant above ground.

" If, as above, twenty ounces of water, at " a medium, perspired in twelve hours day, " (i. e.) thirty-four cubic inches of water, " (a cubic inch of water weighing 254 " grains) then the thirty-four cubic inches " divided by the surface of all the roots, " is = 2286 square inches (i. e.) $\frac{34}{2276}$ is = $\frac{1}{67}$; " this gives the depth of water imbibed by " the whole surface of the roots, viz. $\frac{1}{67}$ part " of an inch.

"And the surface of the plant above "ground being 5616 square inches, by which "dividing the thirty-four cubic inches, viz. "$\frac{34}{5616} = \frac{1}{165}$, this gives the depth perspired by the whole surface of the plant above ground, viz. $\frac{1}{165}$ part of an inch.

"Hence, the velocity with which water "enters the surface of the roots to supply the "expense of perspiration, is to the velocity "with which their sap perspires, as 165 : 67, "or as $\frac{1}{67}$: $\frac{1}{165}$, or nearly as 5 : 2.

"The area of the transverse cut of the "middle of the stem is a square inch; there-"fore the areas, on the surface of the leaves, "the roots and stem, are 5616, 2276. 1.

"The velocities in the surface of the leaves, "roots, and transverse cut of the stem, are "gained by a reciprocal proportion of the "surfaces.

Area of		velocity		or as
leaves	= 5616		$= \frac{1}{5616}$	$\frac{1}{165}$ inch.
roots	= 2276		$= \frac{1}{2276}$	$\frac{1}{67}$ inch.
stem	= 1		= 1	34 inch.

"Now, their perspiring 34 cubic inches "in twelve hours day, there must so much "paſs through the stem in that time; and the

" velocity would be at the rate of 34 inches in " twelve hours, if the stem were quite " hollow."

" In order therefore to find out the quantity " of solid matter in the stem, July 27, at 7, " *a. m.* I cut up even with the ground a sun- " flower; it weighed 3 pounds; in thirty " days it was very dry, and had wasted in all " 2 pounds 4 ounces: that is $\frac{3}{4}$ of its whole " weight: so here is a fourth part left for " solid parts in the stem, (by throwing a piece " of green sun-flower stem into water, I found " it very near of the same specific gravity " with water) which filling up so much of the " stem, the velocity of the sap must be in- " creased proportionably, viz. $\frac{1}{3}$ part more, " (by reason of the reciprocal proportion) that " 34 cubick inches may paſs the stem in " twelve hours; whence its velocity in the " stem will be $45\frac{1}{3}$ inches in twelve hours, " supposing there be no circulation, nor re- " turn of the sap downwards.

" If there be added to 34, (which is the " least velocity) $\frac{1}{3}$ of it $= 11\frac{1}{3}$, this gives the " greatest velocity, viz. $45\frac{1}{3}$. The spaces " being as 3 : 4. the velocities will be " 4 : 3 :: $45\frac{1}{3}$: 34.

"But if we suppose the pores in the surface of the leaves to bear the same proportion as the area of the sap-veſsels in the stem do to the area of the stem; then the velocity both in the leaves, root, and stem, will be increased in the same proportion.

"A pretty exact account having been taken of the weight, size, and surface of this plant, and of the quantities it has imbibed and perspired, it may not be improper here to enter into a comparison of what is taken in and perspired by a human body, and this plant.

"The weight of a well-sized man is equal to 160 pounds: the weight of the sunflower is 3 pounds; so their weights are to each other as 160 : 3, or as 53 : 1.

"The surface of such human body is equal to 15 square feet, or 2160 square inches.

"The surface of a sunflower is 5616 square inches; so its surface is, to the surface of a human body, as 26 : 10.

"The quantity perspired by a man in

" twenty-four hours is about 31 ounces, as " Dr. Keill found. *Vid. Medic. Stat. Britan.* "*p* 14.

" The quantity perspired by the plant, in " the same time, is 22 ounces, allowing " two ounces for the perspiration of the be- " ginning and ending of the night in July, " viz. after evening, and before morning " weighing, just before and after night.

" So the perspiration of a man to the sun- " flower is as 141 : 100.

" Abating the six ounces of the thirty-one " ounces, to be carried off by respiration from " the lungs in the twenty-four hours; (which " I have found by certain experiment to be so " much, if not more) the twenty-five ounces " multiplied by 438, the number of grains in " an ounce *avoirdupois*, the product is 10,950 " grains; which divided by 254, the number " of grains in a cubic inch of water, gives " 43 cubick inches perspired by a man: " which divided by the surface of his body, " viz. 2160 square inches, the quotient is " nearly $\frac{1}{50}$ part of a cubic inch perspired off " a square inch in twenty-four hours. There-

" fore in equal surfaces, and equal times, the " man perspires $\frac{1}{50}$, the plant $\frac{1}{165}$, or as 50 : 15.

" Which excefs in the man is occasioned " by the very different degrees of heat in " each: for the heat of the plant cannot be " greater than the heat of the circumambient " air, which heat in summer is from 25 to 35 " degrees above the freezing point; but the " heat of the warmest external parts of " a man's body is 54 such degrees, and the " heat of the blood 64 degrees; which is " nearly equal to water heated to such a de- " gree as a man can well bear to hold his " hand in, stirring it about; which heat is " sufficient to make a plentiful evaporation.

" *Qu.* Since then the perspirations of equal " areas in a man and a sun-flower are to each " other as 165 : 50, or as $3\frac{1}{5}$: 1; and since " the degrees of heat are as 2 : 1, must not " the sum or quantity of the areas of the " pores lying in equal surfaces, in the man " and sun-flower, be as $1\frac{1}{3}$: 1? for it seems " that the quantities of the evaporated fluid " will be as the degrees of heat, and the " sum of the areas of the pores, taken " together.

" Dr. Keill, by estimating the quantities of " the several evacuations of his body, found " that he eat and drank, every 24 hours, " 4 pounds 10 ounces.

" The sun-flower imbibed and perspired in " the same time 22 ounces; so the man's " food to that of the plant, is as 74 ounces to " 22 ounces, or as 7 : 2.

" But, compared bulk for bulk, the " plant imbibes 17 times more fresh food " than the man; for deducting 5 ounces, " which Dr. Keill allows for the *fæces alvi*, " there will remain 4 pounds 5 ounces of " fresh liquor, which enters a man's veins; " and an equal quantity paſses off every " 24 hours. Then it will be found, that " 17 times more new fluid enters the sap-" veſsels of the plant, and paſses off in " 24 hours, than there enters the veins of " a man, and paſses off in the same time.

" And since, compared bulk for bulk, the " plant perspires 17 times more than the man, " it was therefore very neceſsary, by giving it " an extensive surface, to make a large pro-" vision for a plentiful perspiration in the

" plant, which has no other way of discharging " superfluities; whereas there is provision " made in man, to carry off above half of what " he takes in, by other evacuations.

" For since neither the surface of his body " was extensive enough to cause sufficient " exhalation, nor the additional reek, arising " from the heat of his blood, could carry off " above half the fluid which was necefsary to " be discharged every 24 hours; there was " a necefsity of providing the kidneys to per- " colate the other half through.

" And whereas it is found that 17 times " more enters, bulk for bulk, into the sap- " vefsels of the plant, than into the veins of " a man, and goes off in 24 hours: one rea- " son of this greater plenty of fresh fluid in " the vegetable than the animal body, may be, " because the fluid which is filtrated through " the roots immediately from the earth, is not " near so full freighted with nutritive particles " as the chyle which enters the lacteals of " animals; which defect it was necefsary to " supply by the entrance of a much greater " quantity of fluid. And the motion of the " sap is thereby much accelerated, which in

" the heartlefs vegetable would otherwise be " very slow: it having probably only a pro- " grefsive and not a circulating motion, as in " animals. Since then a plentiful perspira- " tion is found so necefsary for the health of " a plant or tree, it is probable that many of " their distempers are owing to a stoppage of " this perspiration, by inclement air.

" The perspiration in men is often stopped " to a fatal degree; not only by the in- " clemency of the air, but by intemperance, " and violent heats and colds. But in the " more temperate vegetable, perspiration can " be stopped only by inclement air; unlefs by " an unkindly soil, or want of genial moisture, " it is deprived of proper or sufficient nourish- " ment.

" As Dr. Keill observed in himself a con- " siderable latitude of degrees of healthy per- " spiration, from a pound and a half to three " pounds; I have also observed a healthy " latitude of perspiration in this sun-flower, " from 16 to 28 ounces, in twelve hours day. " The more it was watered, the more plen- " tifully it perspired, *(cæteris paribus)* and " with scanty watering the perspiration much " abated."

From these accurate experiments, it is evident that vegetables inspire and expire.—Pure air is necefsary for animals. Vegetables require the same. When obliged to breathe their own vapours, they become unhealthy.—For that reason corn is seldom good in small inclosures; neither are trees healthy when much crowded. The superior goodnefs of the grain produced by the drill and alternate husbandry, evinces the necefsity of a free circulation of air. There is a certain height to which the soil ought to raise the ears of corn. When, from too much closenefs, they are elevated beyond that pitch, the real nourishment that should go to the grain, is spent upon the straw. The stems also that should have been hardened by the air, become weak, and unable to stand against moderate storms of wind and rain.

The culture of beans shows the truth of this observation. When sown too thick, they push themselves upward with seeming vigour, and the crop has the appearance of being a good one. But when examined, we find the pods small, and few in number. On the contrary, when sown in drills, with proper intervals, the straw is shorter, and the pods much larger, and more numerous. I do not argue for the drill husbandry in general; but with regard to beans and turnips, it is a rational and profitable practice.

Farmers may object to the difficulty of keeping the intervals clear of weeds. When hoers cannot be procured, sheep are said to be excellent weeders. The intervals, however, are best cleaned by the common horse-hoe. A drill crop of beans is always superior to a crop sown by the hand. But to return to our philosophical argument.

The analogy that subsists between plants and animals, has induced some very eminent naturalists to suppose a regular circulation of the vegetable juices. M. Perrault, M. Major, M. Marriotte, Malpighi, and our countryman Grew, contended, much about the same time, for the circulation of the sap. According to their microscopical observations, the wood of trees, and the flesh of plants, consist of fine capillary tubes, which run parallel from the root, through the trunk and branches.—These they looked upon as arteries. Other minute vefsels were observed running between the wood and inner bark, which they distinguished by the name of veins. They also described, very correctly, the Tracheæ, or air-vefsels, which take their course through the fibres of the wood. These anatomical preliminaries being settled, they proceeded to reason in this manner.

The root having absorbed a quantity of juice from the earth, it is made to ascend through the vefsels of the wood, by the alternate expansion and contraction of the Tracheæ, afsisted by the natural absorption of the sap-vefsels themselves. They supposed the sap to be rarefied to the degree of a fine vapour, in which state it mounted upward to the extreme parts of the plant, where meeting with the external air, it became condensed into a liquor, and in that form returned to the root by the venal system, between the wood and bark. Dr. Hales, in the most satisfactory manner, set aside this doctrine, and substituted another in its place, more consonant to reason and experiment.

It is something remarkable that Dr. Hervey should have been the first who established the *circulation* of the blood, in opposition to most of the anatomists in Europe; and that Dr.

Hales should have clearly disproved the *circulation* of the sap, contrary to the opinion of almost every naturalist of his time.

In order that we may have a distinct view of the motion of the sap, it will be necefsary to reflect, that the root, stem, branches, and leaves are constructed in the same manner.—Sallows, willows, vines, and most shrubs, will grow in an inverted state, with their tops downward in the earth. Dr. Bradley describes the manner of inverting a young cherry-tree, the roots of which will put forth leaves, and the branches become roots.—Hence it is obvious that the nutritive matter may be conveyed as well by the leaves as the roots, their vascular structure being the very same.

We have now settled the anatomical structure of a plant. Upon it depends much of what we know of the vegetable economy.—The motion of the sap comes next to be examined.

During the heat of a summer's day, all plants perspire freely from the pores of their leaves and bark. At that time the juices are highly rarefied. The diameters of the Tracheæ, or air-veſsels, are enlarged, so as to preſs upon and straiten the veſsels that carry the sap. In consequence of which their juices, not being able to escape by the roots, are preſsed upward, where there is the least resistance, and perspire off the excrementitious parts by the leaves and top-branches, in the form of vapour. When the solar heat declines, the Tracheæ are contracted. The sap-veſsels are enlarged, and the sap sinks down in the manner of the spirits of a thermometer. In consequence of this change, the capillary veſsels of the leaves and top-branches become empty. Being surrounded with the humid vapours of the evening, they fill themselves from the known laws of attraction, and send down the new-acquired juices to be mixed with those that are more elaborated.

As soon as the sun has altered the temperature of the air, the Tracheæ become again distended, and the sap-veſsels are straitned. The same cause always produces the same effect; and this alternate ascent and descent, through the same system of veſsels, continues as long as the plant survives.

The iregular motion of the stem and

branches, is another cause that contributes to the ascent of the sap. Every time that these parts are acted upon by the air, they are made to aſsume a variety of angles, whereby the sap-veſsels are suddenly straitned. The contained juices consequently receive reiterated impulses, similar to what happens to the blood of animals from the contraction of the heart. This observation may aſsist us in investigating the vegetable economy, so far as it regards the management of fruit-trees, and probably may be extended throughout the whole system of gardening, planting, and farming.

It may be objected, that trees fixed to the wall do, notwithstanding, carry their sap to the extreme branches; but it should be considered that the warmth of their situation, aſsisted by the horizontal direction of their branches, is fully ſufficient to propel the sap, without the undulatory motion that I have mentioned.

I beg leave to observe, that these observations are only intended to convey a general idea of the motion of the sap. It varies according to the temperature of the weather. The air is seldom one moment alike. The sap must therefore sometimes move quick, sometimes slow. It may rise and fall many times in a day. Sudden heats push it upward, sudden colds make it fall. Thus the juices are blended, and the secretions forwarded.

The manner that the nutritive juices of the earth and atmosphere are conveyed into the sap-veſsels, remains to be described. And this makes a neceſsary part of our present argument, as it may aſsist us in finding out, and explaining, the diseases of plants from the variations of the weather.

The outer bark which covers every external part of a vegetable, as well below as above the surface, is full of perspiratory or absorbent holes. The veſsels of this bark being endowed with the power inherent in capillary tubes, draw up the moisture that is applied to their surface. From them it is committed to the vessels of the inner bark. After receiving some degree of melioration, the sap is delivered to the blea. From the blea, it paſses, by anastomosing canals, to the vascular series. From thence to the wood, or flesh, where it receives its last concoction.

The nutritive particles being separated by the mechanism of these numerous canals, are applied towards the fructification and increase of the plant; while the watery and excrementitious parts are carried expeditiously to the leaves, where they are perspired off in the form of vapour. It is evident, however, that, as water contains but few particles that are fit for nourishment, it was necefsary that plants should have the power of imbibing a large portion of that fluid. For which reason the sun-flower, considered bulk for bulk, takes in seventeen times more nourishment than a man, and consequently perspires more.

During the continuance of dry north-east winds, the leaves of corn are observed to grow yellow, and the early-set fruit frequently falls off. This is owing to the want of moisture in the atmosphere to fill the vefsels of the leaves and top-branches, whereby the fruit is deprived of nourishment. Under such circumstances, it is probable that wall-fruit may be preserved by prudently watering the leaves and top-branches during the evening. It is, however, a singular happinefs that the air is at no time perfectly free from moisture. Bring a bottle of cold water into the warmest room, and its surface will immediately be covered with a thick dew. An air absolutely dry, would, in a few days, annihilate the vegetable creation.

The air is juſtly said to contain the life of vegetables, as well as animals. It is a compreſsible and elastic fluid, surrounding the face of the globe, and reaching to a considerable height above it. Vegetables do not grow in vacuo, and animals die when deprived of air. It has two states; being either elastic or fixed. Dr. Hales observes, that, in its elastic and active state, it conduces to the invigorating the juices of vegetables; and, in its fixed and inert state, gives union, weight, and firmneſs to all natural bodies. By his experiments we are informed, that fixed air constitutes near one third part of the solid contents of the heart of oak. It is found to bear the same proportion in pease, beans, and other vegetable substances. Heat and fermentation render it elastic. It is again capable of being absorbed and fixed. Was the whole air of the universe brought at once into an elastic and repulsive state, every thing would suffer a sudden dissolution. Was it entirely fixed, then all things would be reduced to an inert lump. Almighty Providence has provided against these extremes, and in the most wonderful manner preserves the balance!

Air is to be found in every portion of earth; and as it always contains a solution of the volatile parts of animal and vegetable substances, we should be careful to keep our stiff soils as open as poſsible to its influence. It paſses, both in its active and fixed state, into the absorbent veſsels of the root, and, mixing with the juices of the plant, circulates through every part. Dr. Hales, in his statical experiments upon the vine, discovered it ascending with the sap in the bleeding season.

Having demonstrated that the motion of the sap depends upon the influence of the air, and the power of absorption common to all capillary tubes, it naturally follows, that it cannot remain one moment at rest. The gradations from heat to cold, and *vice versa*, are infinite, and sometimes desultory: So must the motion of the sap. From the combinations of the nutritive particles, a number of different fluids are prepared in the same plant. Matter is the same in all; but the modification of it makes things sweet or sour, acrid or mild.

The universal juice of a plant is a limpid subacid liquor, which flows plentifully from a wound made in a tree when the sap is rising. The birch and the vine yield it in great abundance. This liquor, as it moves through the innumerable small vefsels, becomes more and more concocted, and is the general mafs from which all the juices are derived. It may be called the blood of the plant. By a certain modification it produces high-flavoured oils, gums, sugar, wax, turpentine, and even the constituent parts of the plant itself. How this transmutation is performed, remains, and perhaps ever will remain, unknown.

I hope it will not be objected to me, that in this efsay I have been too minute. In the history of nature we cannot be too particular: Every part of it demands our most serious attention; and every part of it repays us for the labour we bestow. The wings of the butterfly are painted by the same Almighty hand that made the sun. The meanest vegetable, and the most finished animal, are equally the care of Providence. We constantly view the wisdom of God in his works; and yet, as the wise man observes, "hardly do we guefs aright at "the things that are upon the earth, and with "labour do we find the things that are before "us."

ESSAY VII.

On a new Method of cultivating weak Arable Lands.

VARIOUS are the methods recommended by husbandmen for the cropping of their Lands. Some employ themselves rationally in suiting the crops to the nature of the soil, while others follow the immemorial custom of the village. Farmers, in general, agree in this, that a fallow is necefsary; but they differ as to the time of its rotation. In the scheme of Agriculture recommended by Virgil, there is no change of species. Wheat and fallow succeed each other. Collumella observes the same thing. This seems to have been the foundation of the drill and horse-hoeing husbandry; a scheme pursued with indefatigable diligence by Mr. Tull; but it requires so much nicety and attention, that I apprehend it never will be brought into general use. The principles, however, upon which it is founded ought to be understood by every farmer, as they will enable him to reason properly upon some of the most interesting operations of Agriculture, and lead him insensibly to neatnefs in the management of his farm. I do not mean that he should adopt the theory of Mr. Tull. I would have him only reason upon his practice in regard to the destruction of weeds, and the loosening of the soil.

Reflecting, some years ago, upon the old and new husbandry, I thought that a system might be formed of a mixed nature, that would comprehend the advantages of both, without the inconveniences of either. I was the more desirous of reducing my reasoning into practice, as the plan seemed well adapted to the cultivation of weak arable lands that lie remote from manure.

I am sensible that, by the introduction of turnips and artificial grafses, these weak lands may be cultivated in the most profitable manner; but in wide-extended countries without a hedge, these improvements cannot easily be introduced.

It will be almost unnecefsary to observe, that arable lands have ever been restored by means of a fallow, which the judicious husbandman makes more or lefs frequent in proportion to the poverty of the soil. Upon the high Wolds in Yorkshire, where the soil is poor and thin, oats and barley are principally cultivated. The usual husbandry in open field-land is one crop and a fallow; and in some places, where there is a greater poverty of soil, they are content with a single crop, and then let the land rest for some years to recover itself.

These appear unsatisfactory modes of cultivation. A few straggling sheep, that browse upon the fallows, cannot restore to the earth what the weeds devour. Weeds and corn live upon the same food. To protect the latter, we must destroy the former. Wherever abundance of weeds are observed upon the fallows, we may pronounce the husbandry of the district to be feeble, the husbandman poor, and the rents low. To remedy the defective cultivation of weak arable lands, I have adopted the following system. My practice fully justifies the recommendation.

Instead of having the lands laid out in broad ridges, I order them to be made only nine feet wide. When the seed-time comes, I sow every other land broad-cast, and harrow in the grain in the usual manner. The intermediate ſpaces, which I call the fallow lands, are ploughed two or three times, at proper seasons, by a light plough drawn byone horse, in order to make a clean fallow for the succeeding crop. Upon these lands the seed is sown as before. The stubble in turn becomes the fallow, and is treated accordingly. In this alternate way I manage weak arable lands, and I have the satisfaction to find that very little manure is required, which is a most agreeable circumstance, as such lands are generally remote from a large town. I dare venture to say, that the same field, managed in this alternate way for a few years, will be found to produce one third part more profit, than when cultivated in the usual manner.

Farmers that have large tracts of weak arable land, and live remote from dung, will find this mode both profitable and easy of application. I do not recommend it where the lands are deep and rich—or within a reasonable distance of manure.

To account for the advantages of this culture, we need only reflect that vegetables, no more than animals, can subsist long in a state of health without, the free enjoyment of air.

In a large field, when the weather is calm, the air remains in a state of stagnation, whereby the perspiration of the plants is permitted to continue too long upon the ears of corn. Hence many inconveniences arise to the crop. On the contrary, in the alternate husbandry, the air is constantly in motion. The intermediate fallows serve as funnels to carry it off, and, along with it, all superfluous moisture.

In consequence of this freedom of air, upon which I lay a great strefs, the ears of corn are always observed to be well fed, and the stalks firm and strong. When by severe weather the corn happens to be lodged, it is thrown upon a clean fallow, where it has no chance of being bound down by weeds. It is consequently sooner raised by the current of air which is constantly pafsing along the fallows.

It is, however, the particular happinefs of this method of cultivation, that the corn is seldom laid, even in the most stormy weather.

Turnips, or, when the soil is deep and sandy, a few carrots or potatoes, may be placed upon the intermediate lands: but I have always found it best to keep them as perfect fallows.

Every thing that grows takes something from the soil; and as our land is supposed to be weak, and not supported with much manure, we ought not to suffer the smallest vegetable to take root upon it.

If the farmer chooses he may vary his crops; but I am of opinion, and I speak from some experience, that the same grain may be cultivated, as long as he pleases, upon lands managed in the manner that I have recommended. In consequence of this happy disposition of the soil, every kind of grain may be suited to the land most proper for it. I do not confine the alternate husbandry to oats, barley, and rye. I have tried it upon good wheat land; and if the farmer attends to his businefs, he will find his wheat crops greatly to exceed his expectations. In the cultivation of this grain the utmost attention must be paid to the cleannefs of the fallow lands. For want of proper care in that particular, I was once very unsuccefsful in an experiment of two acres.

In October 1769 I began an extensive trial with wheat upon good land, and as I was desirous of making two experiments at the same time, I manured the sown lands with the oil-compost, at the rate of 9*s. per* acre, which, though an annual charge, may be considered as a trifling sum. At present *(February)* the field looks well, and promises a plentiful crop. I shall minutely attend to every particular, that I may be able to communicate the experiment upon a future occasion.

I acknowledge that many of the advantages of this culture are in common with the drill husbandry; but I flatter myself that there are others which that ingenious system does not enjoy.

I know it will be objected, that in this manner the fallows will be lost to the sheep during the summer months. I answer, so much the better. If pofsible, the fallows should not be permitted to bear a single leaf. The farmer ought to find other ways to support his sheep; and, if he is an intelligent man, he will readily do it. It is an odd kind of husbandry, when the fields bear corn one year for the owner, and the next, weeds for his sheep.

When first I practised this new culture, I was apprehensive that the pigeons and crows would prove my greatest enemies, by settling upon the fallow lands, and pulling down the ears of corn. I have now the pleasure to afsure the public, that, after some years experience, I find my lands no more liable to those depredations than the neighbouring ones.

I need not observe that, by this system of husbandry, the lands are rendered open and light. In consequence of which abundance of nourishment will be conveyed into the body of the soil, instead of being left upon the surface, to be exhaled by the sun, or swept off by the winds. But as the best things sometimes bring inconveniences with them, it will be necefsary to correct this loosenefs of the soil by rolling the lands at proper seasons. For this the husbandman needs no directions.

I have the satisfaction to find that inclosures are begun upon the Lincolnshire and Yorkshire Wolds; in consequence of which, a greater quantity of corn will be produced for a few years than formerly. To such gentlemen as have estates in those counties, or in similar ones, I beg leave to recommend the alternate husbandry. I dare venture to say, that, in point of profit and convenience, it will be found greatly superior to the drill husbandry. The implements used are those of the country, and the mode of cultivation is within the capacity of the meanest ploughman.

ESSAY VIII.

On the Robinia, or, False Acacia; commonly called the Locust Tree.

This tree is a native of North America. Its branches are armed with strong crooked thorns, and garnished with winged leaves, composed of eight or ten pair of oval lobes, terminated by an odd one. They are of a bright green, and sit close to the midrib. The flowers come out from the sides of the branches in pretty long bunches, hanging downward like those of the Laburnum, each flower standing on a slender foot-stalk: These are of the Butterfly, or Pea-blofsom kind; are white, and smell very sweet. They appear in June, and when the trees are full of flowers, they make a fine appearance; but they are of short duration, seldom continuing more than a week in beauty. After the flowers fade, the germen becomes an oblong comprefsed pod, which in warm seasons comes to perfection in England; these ripen late in autumn.

The leaves come out late in the spring, and fall off early in the autumn, which renders this tree lefs valuable than it would otherwise be.

The False Acacia is best propagated by seeds, which should be sown in a bed of light earth about the latter end of March, or the beginning of April; and if the bed has a warm exposure, the plants will appear in six weeks, requiring no other care than keeping them clear from weeds. In this bed the plants should remain till the following spring, when they should be transplanted into the nursery about the end of March, placing them in rows at three feet distance, and a foot and a half asunder in the rows. In this nursery they should remain two years, by which time they will be of size for transplanting into the places where they are designed to grow. As these trees, when they stand long unremoved, send forth long tough roots, it will be advisable to cut them off when they are transplanted. This operation, however, sometimes occasions their miscarrying.

These trees will grow well almost upon any soil, but they prefer a light sandy ground, in which they have been known to shoot six feet in one year. While the trees are young, they make a fine appearance, being well furnished with leaves; but when old, they are rather unsightly, from the branches being frequently broken by high winds, especially when they happen to stand in an exposed situation. In America, this tree is called the Locust Tree. My excellent friend Joseph Harrison, Esq. of Bawtry, has favoured me with the following observations, in a letter dated July 25, 1782.

"The first experiment that I know of, respecting the application of the timber of the Locust Tree, to any purposes in ship-building, was in Virginia, where I resided some time about the year 1733: And, there, happening to be acquainted with an ingenious ship-wright, that had been sent over by some merchants of Liverpool, to build two large ships, I had frequent conversations with him, respecting the qualities of the several principal timber-trees of that country. Being a person of observation, he had made many useful remarks on that subject; which the nature of his employment afforded many opportunities of doing with advantage. He reckoned the Oaks, Elms, Ashes, and many other timber-trees common to both countries, much inferior to the same sorts in England: But frequently spoke of the Locust tree, as of extraordinary qualities both in strength and duration *; and used often to say, if a sufficient quantity could be had, it would be the best timber he had ever met with for building of ships. After he had completed his engagements with his employers at Liverpool, he set a small vefsel on the stocks for himself; but unluckily, not having a sufficient quantity of iron for the purpose, and none being to be had at that time in the country, he was obliged to put a stop to the work, till he bethought himself of the following succedaneum: He had formerly (as hinted above) observed the extraordinary strength and firmnefs of the Locust-tree, and on this occasion took it into his head that Trenails † of that timber

* DURATION. This property has been well ascertained by some pieces of Locust-tree, still continuing firm and sound in some old houses in New England, that were built when the country was first settled.

† TRENAILS, or TREE-NAILS, are wooden pins that fasten the planks to the ribs or timbers;—and to prevent drawing, or the planks starting, they are wedged at both ends, inside and out, so that the strength of a ship depends much on the goodnefs of the Trenails; and if they are not made of wood that is both hard and tough, they will not endure driving so tight as to bear the strain that lies upon

might be substituted for Iron Bolts * in many places where least liable to wrench, or twist, as in fastening the floor-timbers to the keel, and the knees to the ends of the beams, which two articles take up a large proportion of the iron used in a ship, purposing, when he arrived in England, to bore out the Locust Trenails, and drive iron-bolts in their stead. When he first informed me of this scheme, I must own I thought the experiment very hazardous: However, as necefsity has no law, he put it in practice. The ship was built in that manner, loaded, and sailed for Liverpool, where she arrived safe; and though they met with some blowing weather on the pafsage, she never made so much water, but that one pump could easily keep her free. She returned back to Virginia the next year, when I had an opportunity of being informed by the builder himself (who was then captain of her) of what had been the result of his project: He said, that

them; for, in fact, it is the Trenails that hold together the several pieces of which a ship is composed.

* Bolts, are round iron pins, used to fasten the floor-timbers to the keel, and the beams that support the decks to the sides of the ship, and on all other occasions where Trenails are not strong enough to bear the strain that is to be supported.

during the pafsage, especially in blowing weather, he was very attentive in examining the Water-ways*, as, at that place, weak ships are most liable to work and strain, but that he could not perceive any thing more than is usual in other vefsels. When unloaded, she was hauled a-shore upon the bank, in order to be searched both outside and inside; when, on the strictest examination, it was found that the Locust Trenails, that had been substituted instead of Iron Bolts, seemed (to all appearance) to have effectually answered the purpose intended; however, it was thought prudent to take several of them out, and put in Iron Bolts in their room: And this operation afforded another proof of their extraordinary strength and firmnefs; as they endured to be backed†

* The Waterway is that part of a ship's deck that is next to the sides of the ship; this seam, or joint, is very difficult to keep tight, and in weak vefsels will open and shut in carrying sail when it blows hard.

† Backing out a Bolt, or Trenail, is driving it out by means of a tool called a Set-bolt, which is an Iron Punch, something smaller than the Bolt, or Trenail, to be taken out, against which it is driven, with a blacksmith's heavy sledge or hammer: But Oak Trenails, except such as are very hard and sound, will seldom bear this operation: in which case, they are obliged to bore them out with an auger.

out with a Set-bolt, just as well as though they had been Iron; whereas Oak Trenails are usually bored out with an auger. The next voyage the ship made, was to the West Indies, where the Captain died, and with him ended (for the present) any further prosecution of this matter: For though the succefs of the above experiment was known to many, yet (as is frequently the case with new difcoveries) none, that I ever heard of, made any use of Locust Trenails in ship-building, till many years after; though on the goodnefs of that article greatly depends the strength and durablenefs of a ship. I frequently recommended it, when opportunities offered, but all to no purpose, till about twenty years ago, when I was settled in trade at Rhode-Island, I persuaded some ship-builders to try the experiment; but notwithstanding all my endeavours, the use of Locust Trenails still continued to be little practised or known, till it happened to be adopted by a builder of some eminence at New York, and of late years has been introduced into general use there, and in some parts of New England: But as yet the use of the Locust-tree, in ship-building, is confined to the article of Trenails, on account of its scarcity; for, was it near as plentiful as Oak, it would be applied to more purposes, such as knees *, floor-timbers †, foot-hooks ‡, &c. being much superior to it, both as to strength and duration; and from its spreading into branches, affords full as large a proportion of crooks, or compaſs-timber, as the Oak.

" The growth of the Locust-tree has of late been much encouraged in North America: And here, in England, several Gentlemen have propagated great quantities of it, particularly Sir George Savile, who has many thousands now growing in his plantations at Rufford; so that in the next generation, it is probable there may be sufficient for the article of Tre-nails, which alone would be a considerable improvement in the building of ships. At present, the choicest pieces only of the very

* Knees, are those crooked pieces, that, by means of Iron Bolts, fasten the ends of the beams to the sides of the ship.

† Floor-Timbers, are those ribs or timbers that lie acroſs the keel, and are bolted into it.

‡ Foot-Hooks, are those circular ribs or timbers that form the body of the ship from the floor to the top timbers: And all pieces of timber that are not straight, are called crooks or compaſs-timber.

best Oak Timber are applied to that purpose; and as the Oaks of Sufsex are generally reckoned the best in England, most ship-wrights (even those in the north) have their Trenails from thence: And the demand for them is so great, that Trenail-making is there become a considerable manufacture.

"The Locust-tree is not only valuable on account of the excellence of its timber, but its leaves also are useful, and afford wholesome food for cattle *. I knew a Gentleman in New England that sowed several acres for that purpose, which proved a good summer pasture for cows; it is excellent in that country, where the grafs is very apt to fail, from being burnt up by the summer droughts.—Hogs are extremely fond of it, and horses seem to like it.

"The method of propagating the Locust-tree in New England, is by seeds, suckers, or sets, as Willows are here; but the first method is the best, as those plants raised from seeds are found to thrive better and produce larger

* There is a difsertation upon this property of the Acacia in one of the foreign Literary Journals: I think it is the Memoirs of the Imperial Academy at Vienna.

trees than the others. The seeds are first sown in a nursery, and then planted out young into the places where they are to remain.

" Jonathan Acklom, Esq. of Wiseton, has now in his garden a Locust-tree, which, at three feet from the ground, is four feet ten inches in circumference, and sixty feet high: Also another of nearly the same height, but not so thick; and in his nursery are several young plants from the seeds of these trees. They are both, at this time, [July 1782] full of flowers, and likely to produce many seeds, if the remainder of the summer prove favourable. They were raised from seeds brought from North Carolina in 1742, so are now just forty years old."

ESSAY IX.

On a new Species of Grain called Siberian or Haliday Barley.

THE surface of the earth is clothed with a variety of grafses. Such as are intended for the use of cattle are spontaneous in their growth. Such as are intended for man require culture and attention. The grafses of the field yield a never-failing verdure. They shoot early in the spring, and continue to send forth radical leaves, which are daily cropped without injuring the plants. Animals seldom destroy the flowering stems. A variety of grafs-seeds are consequently sown upon our meadows and pastures by the hand of Providence. This dislike in animals to brouze upon the straw that bears the seed, is particularly favourable to the annual grafses, and gives an useful hint to the intelligent husbandman, not to keep his grafs-lands too long under the scythe.

Wheat, oats, barley, and rye are grafses *

* Grafses are one of the seven natural families, into which all vegetables are distributed by Linnæus. They

for the use of man. These vegetables are found in almost every climate. Man is a citizen of the world, and indulgent heaven supplies him with food wherever he goes. The earth produces a variety of grains. Different countries support some kinds more luxuriantly than others. In the northern climates we find plenty of oats and barley. The more southern latitudes are particularly favourable to wheat. Could we look back into the remote annals of time, we should discover that few countries were originally blefsed with the variety of grains and fruits which they at present enjoy. Crabs, sloes, and bramble-berries are the natural fruits of this island; and there was a time when wheat was hardly known. Oats, barley, and rye, fed the vafsal and his lord.

In consequence of a liberal communication with foreigners, we have daily increased the number of vegetable productions, and have,

---

are defined to be plants which have very simple leaves, a jointed stem, a husky Calix, termed Gluma, and a single seed. This description includes the several sorts of corn as well as grafses. In Tournefort they constitute a part of the fifteenth clafs, termed Apetali; and in the Sexual System of Linnæus they are mostly contained in the second order of the third clafs, termed Triandria Digynia.

as it were, naturalized them to our climate. I shall in this efsay give an account of a new species of barley lately brought into this kingdom. As it has been made known to us by the care and attention of Mr. Haliday, I have called it by his name, as an honour due to him. Mr. Haliday, in the most correct and circumstantial manner, communicated his sentiments upon this new species, in a letter to my ingenious friend T. B. Bailey, Esq. of Hope, near Manchester, by whom I am favoured with the following extract.

—— "On the 25th of May, 1767, I received about a moderate wine-glafsful of this grain, from a Member of the Society of Arts, &c. at London, with this information, that a foreign nobleman had presented that Society with about a pint of it, and that it came from Siberia. Not having seen Pontoppidan's account of the *Thor-barley*, or *Heaven's corn*, I was doubtful whether it was the product of a cold or warm climate. The amazing extent of Siberia, and the low latitude of its southern bounds, created this uncertainty. I was from hence induced to divide my small quantity with a neighbouring gentleman, who had in his garden the advantage of glafses and fire. But the result of his trials showed that it was a native of a cold rather than a warm climate. In the morning of the 26th, I sowed the other half, in drills, in a south border of my garden, each grain from four to five inches asunder. The rows were carefully weeded, hoed, and sometimes watered; but, proving rank, I was obliged to support them with stakes and lines. By the latter end of August some few ears were ripened, which I snipped off. I continued this practice, morning and evening, until the first week in October, and laid the ears by in linen bags.

"In April, 1768, I rubbed out by hand the last year's crop, and was happy in finding the quantity was near a quart, equal, if not superior, in quality to the original seed. Having prepared all the south borders in the garden, and part of a last year's potatoe butt in a field adjoining, I sowed the whole in drills, as before, in the first week in May. The crops were kept clean and hoed. What grew in the garden was snipped off as it ripened, and the butt was reaped in the common way on the 28th of August. The whole was hung up in sacks until the beginning of April, 1769, when it was thrashed out, and produced near a bushel.

On the 19th and 20th, having prepared about an acre, of seven yards, pretty fine, I drew drills with a plough about ten inches apart, then a space of three feet, and so on. The grain was sown by hand, and the drills were smoothed with garden rakes. To keep the corn from falling, though, as it happened, there was no need, large beans, were dibbled in the middle of the three-feet spaces. In June, the whole was carefully hand-hoed, and on the 14th and 15th of August was reaped. The calculation I made of the produce from the thraves, proved just about 36 bushels of clean corn.

" Having now got a stock, on which I could afford to make experiments of its utility in the grand points of bread and beer, I had two bushels of 35 quarts, weighing 132 lb. sent to a country mill. When ground, it yielded 80 lb. of fine flour, equal to London seconds, 40 lb. of a coarser sort, and about 12 lb. of bran, superior to wheat bran. The best flour made excellent bread, sufficiently light, and so retentive of moisture, as to be as good at twelve or fourteen days after baking, as wheaten bread on the fourth day. But, to give it the fairest trial, I had 12 lb. of the barley, and

12 lb. of wheat flour, equally fine, kneaded with some yeast, and baked in the same oven. The wheaten loaf weighed 15 lb. and the barley 18 lb.

" These trials sufficiently established its excellence as a bread-corn. The foregoing year had proved its fecundity. To find out its quality for ale, I readily accepted the offer made me by a Gentleman of Liverpool, of equal ſkill and attention, and sent him two bushels to be malted. He obligingly took the trouble of this small quantity, and made me happy in the account he gave me of its working.

" In the latter end of January, it was brewed into a half-barrel of ale, and another of small beer. The latter was used at a month old, and proved good. The ale was tapt on the 27th of May, and proved of a fine colour, flavour, and body*.

" You have now all the particulars of my

---

*Dr. Lochster, in his Diſsertation de Medicamentis Norwegiæ, extols the liquor made of it both as palatable and wholesome. " Palmam, (says he) quoque reliquis præripit decoctum hordei cœlestis, vulgo Himmelbyg, grato tam sapore quam effectu se commendans."

three years experience of this excellent grain. If you think the information can be of service to your farming acquaintance, you are at liberty to use it as you please, hoping, however, that my succefs will apologize for my enthusiasm in its favour. The idea I entertain of its superior utility to any other spring-corn, has induced me to make it as universally known as the narrow circle of my acquaintance would permit. I thank you for afsisting my views, and am in hopes that Mr. Young will find occasion to celebrate its virtues from a more skilful, though not a more attentive cultivation.

"On the 30th of April, I laid down, in the broadcast way, two large acres, of eight yards, with six bushels and a half of this barley, white clover, and hay-seeds, and have sown four other bushels in a field of poor natural soil. Both fields look well. I am also happy in knowing that about 20 bushels of my last year's crop are now under skilful culture in the several counties of Kent, Surry, Efsex, Middlesex, Hereford, Stafford, Chester, Derby, York, Durham, and many parts of this County; in two or three counties in Wales, six or seven in Ireland, and some in Scotland; from all which I am filled with the hopes of its soon becoming as universally esteemed as known."

ESSAY X.

On Potatoes.

When first the Potatoe was brought into England, it was supposed to poſseſs some noxious qualities; but the experience of many years has proved it to be a wholesome and nourishing root.

Every kind of plant delights in a particular soil. The potatoe thrives best in a light loam. Its roots being tuberous, they could not swell in a stiff clay.

In a former eſsay, I recommended a strict attention to the shape of the roots of such plants as were the objects of field-husbandry. That anatomical investigation will aſsist us in the rational cultivation of all kinds of vegetables. The roots of oats are strong and piercing; they are therefore formed by nature to seek their paſsage through land but imperfectly tilled, which accounts for the excellent crops of that grain produced upon a single ploughing. The roots of wheat and barley are, on the contrary, tender and fibrous: they consequently require a finer tilth. Beans are tap-rooted. Afsisted by their wedge-like form, they pierce through the toughest soils.

I need not run through all the plants of the field, to prove that each has a choice of soil. In this the animal and vegetable worlds perfectly agree, and a small degree of reflection will enable us to trace the affinity.

The potatoe may be considered as a certain relief to the poor against a deficiency of the corn harvest: for that reason it requires our most serious attention. Various are the methods recommended for its cultivation. Practical books of husbandry circumstantially relate them. I therefore judge a regular detail unnecefsary in this place.

As this most useful root delights in a loose soil and a great deal of sun, we should anxiously endeavour to obtain these ends in all the modes of cultivation. When raised in hillocks the earth lies light upon the spreading roots, and the sun has free accefs to the crown of the hills by the falling down of the haulm into the surrounding trench. By the frequent earthings that are required in this manner of culture, the soil is kept clear of weeds, and the whole field is reduced into the form of a garden. This is a very profitable method of cultivation, and the expense attending it is not so considerable as might at first be imagined. Two men and a boy will plant an acre in four days, the expense of which must be estimated according to the rate of labour in the country. Two men will give the second and last earthing in three days. I usually place the hills in the quincunx form, measuring four feet from centre to centre. Into each hill I put five cuttings, placing one in the middle, and the others round it. Excellent crops may be obtained by putting one large potatoe into the centre of each hill. When the land is fresh, and the busineſs has been well attended to, the cultivator may expect near a peck of potatoes in each hillock; which is a larger produce than can be obtained by any other method.

It will here be neceſsary to observe, that the spade, where hands can be procured, is greatly preferable to the plough; but, in countries where they are scarce, the plough is a good instrument, provided the farmer takes care to allow a sufficient distance between the rows, in order to destroy the weeds, and throw fresh mould up to the plants. This distance should not be lefs than three feet, especially in shallow soils.

It is customary to put the manure over the sets, but the practice is injudicious. By attending to the manner that the potatoe grows above and below ground, we may be enabled to form very correct rules of cultivation.

As soon as the potatoe puts forth its stalk, in order to rise to the surface, it sends out several strong roots which run obliquely downward, and may be called the feeding roots. They do not produce fruit. When the manure is placed under the sets, the feeders pierce into it, and extract the oily and mucilaginous particles. The potatoe creeps under-ground, and, in proportion to the covering of earth, the stalk within the ground becomes longer or shorter. From this stalk lateral shoots are detached, which are bearers. These bearers are, in fact, branches within ground. They go off from the descending stalk in the same manner and distance as the branches do from the ascending one. Had they appeared upon the surface, they would have brought forth leaves, flowers, and apples, but being confined they produce potatoes.

In the sixth eſsay, I have demonstrated that all the parts of a plant are the same; the only difference lies in the shape. Trees may be planted with their roots in the air, and their branches in the earth. In that state they will live and grow. A fibrous root that has escaped through the earth, becomes a tree perfect in all its parts. The tops of potatoes, cut off in June and planted in the earth, will take root, and produce a good crop. I have observed that the bearing shoots go off from the main root in the manner of the branches from the main stem; consequently, we are directed to lengthen the main root, in order to increase the number of bearing shoots. This is accomplished by giving frequent earthings to the plant. That operation, however, requires discretion. For when too great a load of earth has been thrown up, as in hillocks, the lowest shoots being deprived of the sun and air, either become barren, or produce very small fruit. Potatoes planted in drills are not subject to this inconvenience. In general they have too slight a covering of earth, so that they seldom put out above one layer of bearing shoots. There is another objection to this method: for unlefs the bearers run in the direction of the drills, they escape at the sides, and ascend in a stalk, which bears leaves and flowers instead of potatoes. The haulm also of one row falls upon the crown of the contiguous one, which, by keeping out the sun, diminishes the crop. When cultivated in hillocks, the haulm falls down into the trench, leaving the crowns exposed to the solar heat. The potatoe delights in the sun, and cannot bear the shade; for which reason we should be careful, in all the modes of cultivation, to preserve this bias of nature.

In some places it is usual to dibble in the sets at sixteen inches distance on a flat surface. The land requires a good drefsing of rotten dung, and must have deep stirrings with the plough, if the staple of the soil will admit of it.

Soon after the appearance of the plants, the intervals should be carefully hand-hoed, which operation must be repeated occasionally.—

Some people trench with the spade, placing long litter at the bottom of the trenches; after which the sets are dibbled in. This is a good but expensive method. It is agreeable to the nature of the plant, as it encourages the running of the bearing shoots.

In whatever manner potatoes are cultivated, unleſs upon fresh land, dung must be used. It is an error to say that they do not exhaust the soil. On the contrary, they impoverish greatly; against which there is no remedy but plenty of dung and clean huſbandry.—Under these circumstances they may be considered as an ameliorating crop.

In very coarse clays I have raised large crops of this root in hillocks, where it would have been impoſsible to have cultivated them in drills. The reason is obvious.

Of potatoes there are various kinds, and we are every day adding to their number by the industry of such gardeners as raise them from the apple. I shall only remark, that the sorts which yield the greatest increase are the most proper for the farmer. The early and tender kinds come more immediately under the care of the gardener.

In this general view, the reader will observe, that I do not consider the potatoe itself as the root of the plant, but rather as an under-ground fruit, produced upon a confined branch. The real roots do not produce potatoes; they only serve the purposes of drawing nutriment from the soil, in the same manner that the leaves above extract it from the atmosphere. The apple above, and the potatoe below, are, in fact, the same; but, living in different elements, they afsume different appearances. The one seems to have been intended for the food of animals, and the other for the preservation of the species.

ESSAY XI.

On the culture of Turnips.

THE drill method of raising turnips is generally practised by such Farmers as wish to be considered in the light of correct husbandmen. The broadcast, or old method, is, however, better adapted to the generality of farmers. The instruments used are plain and simple in their structure, easy and familiar in their application. The drill system requires complicated machinery, and being founded upon principles, demands a degree of reasoning to understand it. After which, the practice requires a spirited kind of attention, not to be met with in every village.

I do not propose to give a comparative view of the two methods. My intention in this efsay is only to throw a general light upon the drill culture of turnips, and to point out to the plain farmer an easy and certain method of raising a large crop upon almost any soil.

The land being well ploughed and harrowed, but not manured, furrows must be drawn all over the field with the common plough, at three feet distance. These open furrows must nearly be filled with rotten dung. This operation is conducted by women and children, as usual in setting potatoes. After this the earth must be returned into the furrow, by a light plough drawn by one horse. The whole field being now disposed in ridges at three feet distance, the seed must be sprained upon them from the fingers: after which a bush-harrow must be brought in to cover the seed, or a person with a rake may follow the seedsman. For the purpose of sowing the seed, I always make use of the hand-drill described by Mr. Young in the first volume of his Northern Tour. It is a cheap instrument, and does the work with expedition and certainty. In drilling of turnips, the farmer should be advised not to be sparing of seed; for, as the rows undergo the operation of the hand-hoe, there can be no danger from a superfluity of plants.

As soon as the turnips have got into the rough leaf they must be thinned by the hand-hoe, which operation may be performed by common servants. Broadcast turnips, on the contrary, require the utmost dexterity. This I esteem a material advantage.

When the weeds come up in the intervals, they must be turned down by ploughing a furrow from the turnips, which will leave an arch of earth between the rows. At a proper season, when the weeds advance, this arch must be split, so that the turnips will be left upon ridges, with a trench in the place of the former arch. The rows should undergo a second hoeing; and if any double turnips are left, they must be removed by the hand. Women and children perform this operation with great expedition.

It is impoſsible to conceive a finer sight than a field of turnips dreſsed in this manner. The expense appears to be great; but the superior excellence of the crop, added to the cleanneſs of the land, will much more than over-balance the additional expense and trouble. I do not take upon me to estimate the expense of this method of culture, as it depends greatly upon the addreſs of the persons employed; on which account the second year will be leſs expensive than the first.—I do not mean to confine the farmer to a servile obedience to the rules that I have laid down. If he only observes the general principle of laying the manure at the bottom of the furrows, he may reduce every other part of the operation to his own sentiment.

Mr. Benson, an excellent farmer and ingenious mechanic, who lives in the neighbourhood of Ripon, is the person that contrived the above mode of cultivation, and has followed it himself for many years, with great succefs. His method varies in some particulars from what I have described. He drills the seed upon the dung, and draws the earth over it with a kind of harrow without teeth. It is something of the shape of a crooked elbow. I believe this method is better than what I have described, especially in sultry weather. The seed, when placed upon the moist dung, and covered with the earth, soon vegetates, and pushes upwards with surprising vigour. The plants being strong, soon get into rough leaf, and by that means escape the ravages of the fly. I once sowed an acre of turnips in this manner during a sultry season. The plants were up on the seventh day, while the broadcast part of the same field did not show the least appearance till the fourteenth day after sowing. The field was sown at the same time, and the only difference lay in the culture. In hot and sultry weather the manure, as commonly used, is exposed to the scorching rays of the sun; great part of it is consequently exhaled. But when confined in the furrows, the exhalation from it is absorbed by the earth, and retained.

It may here be observed, that the above method does not efsentially differ from the drill and horse-hoeing culture, excepting in the distribution of the manure.

The horse-hoeing method begins to gain ground in this country. It is far superior to the broadcast, especially in districts where expert hoers cannot be procured.

An ingenious friend of mine now raises excellent crops of turnips by the help of the drill and horse-hoe, where that useful vegetable is scarcely known. What few are raised in his neighbourhood are so overrun with weeds for want of hand-hoeing, that the crop becomes destructive both to the landlord and tenant. He has been so obliging as to communicate to me his sentiments upon this head, which, I dare say, will be useful to such farmers as are desirous of raising large and clean crops of turnips at a small expense.

This ingenious cultivator brings the land destined for turnips into excellent tilth by frequent ploughings. At the last stirring which is about Midsummer, either a little before or after, according to the season, he harrows the land very fine, and, with the hand-drill described in the first volume of Mr. Young's Northern Tour, sows the seed in rows at two feet and a half distance. After this the land is harrowed once over with light harrows, in order to cover the seed. When the turnips are up and pretty strong, they are set out at about a foot distance with the hand-hoe.— When the land is much infested with weeds, he ploughs two furrows from the rows to the centre of the intermediate space; and when the weeds make a second shoot, he splits the ridge with a horse-hoe with a double mould-board. When the land is not very foul, the latter operation is sufficient without the former. In this manner a large and clean crop of turnips may be procured with very little afsistance from the hand-hoe.

In countries where hands are scarce, this is an excellent and judicious method. Every person may introduce such variations as may suit his own convenience, provided he takes care to preserve the general principle.

I have known a large field of broad-cast turnips very well hoed, by cutting them into stripes with a light plough, and afterwards hand-hoeing the stripes by common labourers. This method is no despicable one in countries where hands are scarce. Women and children at a small expense, may afterwards be sent into the field to draw the double turnips, and set out the whole in a correct manner.

ESSAY XII.

On the Culture of Carrots, and their Use in fattening of Hogs.

IN the year 1769, I took two acres of rich sand land, which the year before had been ploughed out of swarth, and had borne a crop of very fine cabbages. About the 27th of March I ploughed and cleared the land from the cabbage stalks, and grafs that had grown between the rows, and prepared it without putting any manure upon it, for sowing my carrots in the following manner.—A plough with two horses drew a furrow of the common depth, and was followed by another plough with two horses in the same furrow, which turned up the soil ten or twelve inches deep. This is called double ploughing. Two ploughs will do about an acre a day. On the 5th of April I sowed the seed, about four pounds to an acre. My gardener finished the two acres with ease in a day, having mixed the seed with about a bushel of dry sand. The seed was immediately harrowed in. When the carrots were about a month old, I sent some women into the field to hoe them. The hoes were only three inches broad. I afterwards had the field weeded twice by the hand, which, although very expensive, I found to be infinitely the best way. The crop when taken up weighed twenty tons without the tops. I shall now proceed to the expense of cultivating these two acres of carrots.

	£.	s.	d.
Rent, ...	3	0	0
Taxes, ...	0	4	0
Two days ploughing with two ploughs,	0	14	0
Three days harrowing, ...	0	9	0
Cleaning the ground from the cabbage stalks, &c.	0	6	0
Eight pounds of seed, ...	0	12	0
A man one day sowing	0	1	6
Hoeing, ...	0	15	0
Hand-weeding, first time, ...	1	0	0
Ditto*, second time, ...	1	11	6
	£8	13	0

* The reason why the second weeding cost more than the first, was because the women had sixpence per day, it being hay-time, whereas the first time they had only fourpence.

Mr. Young, in his treatise upon the management of hogs, is of opinion that boiled carrots are the best food for fattening that useful animal. He prefers them to pollard, white pease, buck wheat, or potatoes. I beg leave to transcribe the experiment upon which he founds his opinion.

" In January, 1766, I drew from the herd ten hogs, as equal in size as pofsible, and weighed them alive in five lots.

		S.	P.
N° 1.	weighed	13	4
2.	———	12	6
3.	———	13	0
4.	———	12	11
5.	———	13	1

" A nearer equality than this, in matters that can neither be added to nor diminished, can scarcely be expected.

" N° 1. was fatted with white pease, that weighed sixty-six pounds per bushel, the price 30s. per quarter.

" N° 2. with pollard, that weighed twenty-two pounds per bushel, the price 9d. per bushel.

"N° 3. with buck-wheat, that weighed forty-seven pounds per bushel. the price 2s. 3d. per bushel.

"N° 4. with boiled potatoes, that weighed fifty-four pounds per bushel, the price 2s. per bushel.

"N° 5. with boiled carrots, that weighed raw fifty-five pounds per bushel, the price 1s. 1d. per bushel.

"I thought it best to fix on a given sum, as proper to fat each hog. The people I consulted were of opinion, that eight bushels of white pease were necessary to fat one such hog well. This I accordingly fixed on as my criterion. The account of the expense therefore stood thus:

				£.	s.	d.
N° 1. Pease, 16 bushels, - - -				3	0	0
2. Pollard, 80 bushels, - - -				3	0	0
3. Buckwheat, 27 bushels, - -				3	0	9
4. Potatoes, 28 bushels, -		2	16			
Labour and Coals, - -			4			
				3	0	0
5. Carrots, 49 bushels,	2	13	2			
Labour and Coals,		6	10			
				3	0	0

" Each lot was weighed as soon as the food was done. The result was as follows:

			S.	P.
N°	1.	weighed	27	6
	2.	———	27	9
	3.	———	29	13
	4.	———	25	7
	5.	———	31	0

" It is evident from this experiment, that carrots boiled are superior to any other food. I did not expect that potatoes would be so much inferior; but I have found from divers other trials since, that it is requisite to mix the meal of somekind of corn with them. Pollard in this trial, as in the last, is superior to pease."

From this experiment of Mr. Young, the boiled carrots appear in a favourable light. I was therefore induced to follow his advice, and accordingly bought in twelve hogs as follows;

			S.	P.
N°	1.	———	15	2
	2.	———	16	0
	3.	———	14	12
	4.	———	13	13
		Carried over	59	13

	S.	P.
Brought over	59	13
N° 5. ———	12	6
6. ———	17	2
7. ———	14	10
8. ———	13	3
9. ———	16	10
10. ———	17	0
11. ———	12	10
12. ———	13	6
	177	4

On the 26th of October, 1769, I put them up to feed upon boiled carrots, which they eat with seeming pleasure. On the 28th of December I weighed them again, being fat, and found that they had gained, in the nine weeks, just 33 st. 10 lb. During this period they consumed 574 bushels of carrots, at 4 st. per bushel.

	l.	*s.*	*d.*
These 574 bushels, if estimated at 1 s. 1 d. per bushel, would have cost	34	13	10
Attendance, fire, &c. for nine weeks,	3	12	0
	£. 38	5	10

A farmer presuming upon Mr. Young's experiment, and purchasing carrots at 1 s. 1 d. per bushel, would just give 38 l. 5 s. 10 d. for 33 st. 10 lb. of live flesh.

Thus far I have related my experiment, and so far it accompanies Mr. Young's. The difference in the result is amazing. Mr. Young gets 17 st. 13 lb. of live flesh for 3 l. I pay 38 lb. 5 s. 10 d. for 33 st. 10 lb. which is upwards of 23 s. per stone.

It will be unnecefsary to make many reflections upon the result of this interesting experiment. I shall only observe, that every thing relative to it was conducted with that care and attention which trials of this important nature require. Towards the latter end of fattening, I found it necefsary to bestow upon the hogs as much bean meal as cost me 6 l. without which the bacon would not have been marketable.

Willing to carry my trial as far as it could be prosecuted, I killed the hogs. When dried, they weighed, without the cheeks, 104 st. which sold in the London market for 40 s. a hundred. The cheeks were valued at half a crown a piece. In the course of drying, the bacon lost upwards of 70 st. which great consumption was, in some degree, made up by the excellence of its quality.

	l.	*s.*	*d.*	*l.*	*s.*	*d.*
Prime cost of 12 hogs,	22	9	0			
Bean meal,	6	0	0	32	1	0
Fire and attendance for nine weeks,	3	12	0			
Value of the bacon and cheeks,				27	10	0
Lofs £.				4	11	0

From the above experiment it is plain, that we fhould not depend upon carrots *alone* for fattening of hogs. A judicious *mixture* of food conftitutes the moft rational and profitable method. Mr. Young makes his carrots worth 13d. a bufhel in fattening. I lose upwards of 4l. befides 574 bufhels of carrots, which I could have sold for 28l. It may be proper to obferve, that my hogs, being much larger than Mr. Young's, eat a proportionable quantity of carrots before they were fat. This difference in size may probably account, in some degree, for the different results of our experiments.

ESSAY XIII.

On the Study of Nature.

THE study of nature is one of the most pleasing amusements that can engage the mind of man. The entertainment that it gives, is as infinite as the variety of the subjects of which it is composed. When we consider the history of nature as interwoven with religion, our breast is immediately opened, and the divine goodneſs sinks down into the heart with energy and conviction. Akenside beautifully expreſses himself when he says,

——————————The men
Whom nature's works can charm, with God himself
Hold converse; grow familiar, day by day,
With his conceptions; act upon his plan,
And form to his, the relish of their souls.

Wherever we cast our eyes, a field of contemplation opens to our view. The animal, vegetable, and mineral worlds teem with matter for the exercise of our minds.

Man, in a state of nature, is obliged to his industry for meat and clothing. He is born naked and defencelefs. Early he leaves the fostering hands of his parents, and goes into the wide world, where his understanding must supply the wants of nature. Being a social animal, he herds with his fellow-creatures. Societies are formed for mutual protection. Providence having bestowed upon man, from the beginning, all manner of power over the beasts of the field, the fowls of the air, and the fishes of the sea, he executes his power, and subjects them to his will. The vegetable creation lies open to his view. Minerals, though hid in the bowels of the earth, yield to his industry. For him all things seem to have been made. Every thing ultimately resolves itself into the ease, comfort, and satisfaction of man. Whether we consider them as supplying his natural wants, or contributing to his artificial desires, the argument is still the same: He is lord of all, and enjoys the whole.

Over some animals he is forced to exercise command. Others follow him, and cannot exist without his protection. Sheep that supply him with food and clothing, stand most in need of his afsistance. They lodge, as it were, in his bosom—and are never found in countries untrod by man.

The face of the globe is covered with a lasting verdure for the use of animals that are friendly to man. In every country, and in every place, the bountiful earth brings forth its fruits in due season, and rewards the industrious care of the husbandman. Corn is spontaneous in no climate, but the industry of man can raise it in all.

The just contemplation of the works of Providence is the humble adoration of a Christian. He views, with gratitude, the good things that God has made, and enjoys them cheerfully. Let the melancholy Recluse shrink into his wretched habitation, and, with himself, bury the gloomy horrors of his mind. God delights in the cheerful contemplation of his works. The Saviour of the world bids us *consider the lilies of the field how they grow ; they toil not, neither do they spin* ; *and yet Solomon in all his glory was not arrayed like one of these.*

The regular return of seasons, and the invariable order that vegetables observe in budding, leafing, and flowering, bespeak almighty wisdom and almighty power. A mind harmonized to such divine contemplations, sees at all times, and feels with warmth, the goodneſs of the Creator to the created. He considers the works of nature as the silent, but expreſsive language of the Diety; and while he seems only to admire, is wrapt in gratitude and devotion.

ESSAY XIV.

On the Time of Sowing.

MR. Harold Barck, in his ingenious diſsertation upon the foliation of trees, published in the Amæn. Acad. Vol. III. informs us, that the illustrious Linnæus had, in the most earnest manner, exhorted his countrymen to observe, with all care and diligence, at what time each tree expands its buds and unfolds its leaves; imagining, and not without reason, that his country would, some time or other, reap some new and perhaps unexpected benefit from observations of this kind made in different places.

As one of the apparent advantages, he advises the prudent husbandman to watch, with the greatest care, the proper time for sowing; because this, with the divine aſsistance, produces plenty of provision, and lays the foundation of the public welfare of the state, and of the private happinefs of the people. The ignorant farmer, tenacious of the ways and customs of his anceſtors, fixes his sowing season generally to a month, and sometimes to a particular day, without considering whether the earth be in a proper state to receive the seed; from whence it frequently happens that what the sower sowed with sweat, the reaper reaps with sorrow. The wise economist should therefore endeavour to fix upon certain signs whereby to judge of the proper time for sowing. We see trees open their buds and expand their leaves, from whence we conclude that spring approaches, and experience supports us in the conclusion; but no body has as yet been able to show us what trees Providence has intended should be our kalendar, so that we might know on what day the countryman ought to sow his grain. No one can deny but that the same power which brings forth the leaves of trees, will also make the grain vegetate; nor can any one afsert that a premature sowing will always, and in every place, accelerate a ripe harvest. Perhaps, therefore, we cannot promise ourselves a happy succefs by any means so likely, as by taking our rule for sowing from the leafing of trees. We must for that end observe in what order every tree puts forth its leaves according to its species, the heat of the atmosphere, and the quality of the soil. Afterwards, by comparing together the observations of the several years, it will not be difficult to determine, from the foliation of the trees, if not certainly, at least probably, the time when annual plants ought to be sown. It will be necefsary likewise to remark what sowings made in different parts of the spring produce the best crops, in order that, by comparing these with the leafing of trees, it may appear which is the most proper time for sowing.

To these most ingenious remarks, Mr. Barck has added the order of the leafing of trees in Sweden. Mr. Stillingfleet is the only person that has made correct observations upon the foliation of the trees and shrubs of this kingdom. The following is his kalendar, which was made in Norfolk in the year 1765.

1	Honey-suckle - - - - -	Jan.	15
2	Gooseberry - - - - -	March	11
3	Currant - - - - - - - - - -		11
4	Elder - - - - - - - - - -		11

5	Birch - - - - - - -	April 1
6	Weeping Willow - - - - - -	1
7	Raspberry - - - - - - - -	3
8	Bramble - - - - - - - - -	3
9	Briar - - - - - - - - - -	4
10	Plumb - - - - - - - - -	6
11	Apricot - - - - - - - - -	6
12	Peach - - - - - - - - - -	6
13	Filberd - - - - - - - - -	7
14	Sallow - - - - - - - - -	7
15	Alder - - - - - - - - - -	7
16	Sycamore - - - - - - - -	9
17	Elm - - - - - - - - -	10
18	Quince - - - - - - - - -	10
19	Marsh Elder - - - - - - -	11
20	Wych Elm - - - - - - - -	12
21	Quicken Tree - - - - - - -	13
22	Hornbeam - - - - - - - -	13
23	Apple Tree - - - - - - -	14
24	Abele - - - - - - - - -	16
25	Chesnut - - - - - - - -	16
26	Willow - - - - - - - -	17
27	Oak - - - - - - - - -	18
28	Lime - - - - - - - - -	18
29	Maple - - - - - - - - -	19
30	Walnut - - - - - - - -	21
31	Plane - - - - - - - - -	21
32	Black Poplar - - - - - - -	21

33	Beech - - - - - -	April	21
34	Acasia Robinia - - - - -		21
35	Ash - - - - - - - - - -		22
36	Carolina Poplar - - - - -		22

In different years, and in different soils and expositions, these trees and shrubs vary as to their leafing; but they are invariable as to their succefsion, being bound down to it by nature herself. A farmer, therefore, who would use this sublime idea of Linnæus, should diligently mark the time of budding, leafing, and flowering of different plants. He should also put down the days on which his respective grains were sown; and, by comparing these two tables for a number of years, he will be enabled to form an exact kalendar for his spring corn. An attention to the discolouring and falling of the leaves of plants, will afsist him in sowing his winter grain, and teach him how to guefs at the approach of winter. Towards the end of September, which is the best season for sowing wheat, he will find

The leaves of the plane tree, tawney;
——— of the oak, yellowish green;
——— of the hafsel, yellow;
——— of the sycamore, dirty brown;
——— of the maple, pale yellow;

The leaves of the ash, fine lemon;
——— of the elm, orange;
——— of the hawthorn, tawney yellow;
——— of the cherry, red;
——— of the hornbeam, bright yellow.

There is a certain kind of genial warmth which the earth should enjoy at the time the seed is sown*.

Vere tument terræ et genitalia Semina poscunt. VIRG.

In the animal world we observe this in the most convincing manner. In brutes the symptoms of that period are plainly marked. The budding, leafing, and flowering of plants, seem to indicate the same happy temperature of the earth.

Appearances of this sublime nature may be compared to the writing upon the wall, which

* In the North of England, when the earth turns up with a mellow and crumbly appearance, and smoaks, the farmers say the earth is *brimming*. This state is but of short duration, and shows the exact time when the seed should be sown. This appearance will ever coincide with the budding, leafing, flowering, &c. of some plants that grow in the field. The husbandman should therefore, at that time, make his observations, in order to form his kalendar of Flora.

was seen by many, but understood by few. They seem to constitute a kind of harmonious intercourse between God and man. They are the silent language of the Deity.

The ingenious and indefatigable Mr. Young has endeavoured to ascertain the time of sowing by another method. His experiments are accurately conducted, and his conclusions from them fairly drawn; but it were to be wished that he had interwoven the idea of Linnæus with his own experiments; we should then have had an unerring rule to go by: The temperature of the season, with respect to heat and cold, drought and wet, differs in every year. Experiments made this year cannot determine, with certainty, for the next. They may afsist, but cannot be conclusive. The hints of Linnæus constitute an universal rule for the whole world, because trees, shrubs, and herbs, bud, leaf, flower, and shed their leaves, in every country, according to the difference of seasons.

In order to induce some careful observer to prosecute this useful inquiry, I shall select some of Mr. Young's experiments, as an excellent pattern to go by; and I flatter myself that the observations in the former part of this efsay, will be sufficient to direct him in combining the experiments of the field, with the sublime ideas of the philosopher.—The experiments I refer to are recorded in the first volume of Experimental Agriculture, under the article Wheat.

" Experiment V. p. 293.

" In 1765, I marked several drills, each a perch long, in a piece of fallow. The soil a loose woodcock loam on the surface, and under that a clay. Sowed each with an ounce of wheat, at the following times:

N°. 1.	August	18
2.	———	31
3.	September	10
4.	———	17
5.	———	24
	Ploughed again.	
6.	October	1
7.	———	13
8.	———	20
	Another ploughing.	
9.	———	31
10.	November	9
11.	———	16

Another ploughing.

12.	November	23
13.	December	3
14.	———	13

"The drills in all the experiments were two feet asunder. They were all hand-hoed at the same time.

The Produce.

N°. 1.	———	$6\frac{1}{2}$ ounces
2.	———	$6\frac{1}{2}$
3.	———	$6\frac{1}{2}$
4.	———	$6\frac{1}{4}$
5.	———	$6\frac{1}{4}$
6.	———	$6\frac{1}{2}$
7.	———	$5\frac{1}{2}$
8.	———	$5\frac{1}{4}$
9.	———	5
10.	———	5
11.	———	$5\frac{1}{4}$
12.	———	$4\frac{3}{4}$
13.	———	$3\frac{1}{2}$
14.	———	3

"This experiment, though not decisive in every point, is very important in the result of late sowing. October is, in Suffolk, supposed to be the best time for wheat-seed sowing:

but this shows that September is at least equal, if not superior: and, what would astonish one half of the farmers in the country, is, that the latter part of August is as good as either; but after October the product decreases; and in December it comes to a trifle. This effect is particular, as the latter sown corn had the advantage of three ploughings more than the early.

"EXPERIMENT VI. p. 294.

"In 1765, marked some perches of fallow in the same field, and sowed them each with one ounce of seed, at the following times:

N° 1.	August	23
2.	———	31
3.	September	3
	Ploughed again.	
4.	September	16
5.	———	21
6.	———	28
	Another Ploughing.	
7.	October	7
8.	———	16
9.	———	26

	Another ploughing.	
N° 10.	November	4
11.	———	14
12.	———	20
13.	———	28
	Another Ploughing.	
14.	December	6
15.	———	12
16.	———	18

" Hoeing, cleaning, &c. performed on the same days.

THE PRODUCE.

N° 1.	produced	$5\frac{1}{2}$ ounces.
2.		$5\frac{3}{4}$
3.		$7\frac{1}{4}$
4.		$6\frac{1}{2}$
5.		$6\frac{1}{4}$
6.		6
7.		$6\frac{1}{4}$
8.		6
9.		$5\frac{1}{2}$
10.		$5\frac{1}{4}$
11.		5
12.		$4\frac{3}{4}$
13.		5
14.		$4\frac{1}{2}$
15.		$4\frac{1}{2}$
16.		$4\frac{1}{4}$

"This experiment, like the last, appears to me to have an important result. So early as August, seems to be somewhat improper for sowing: from the beginning of September to the middle of October, the most advantageous season: November bad, but December worse; and this degradation, notwithstanding the progrefsion of ploughing, which is a material point, and by no means to be overlooked.

"EXPERIMENT VII. p. 295.

"In 1765, marked some perches of fallow in a field consisting of a light gravelly loam, and sowed them each with one ounce of seed, at the following seasons:

N° 1.	August	23
2.	September	3
3.	———	10
	Fresh Ploughed.	
4.	September	21
5.	———	28
6.	October	4
7.	———	11
8.	———	18

Another ploughing.

Nº 9.	October	25
10.	November	2
11.	———	9

Another ploughing.

12.	November	16
13.	———	23
14.	———	30

Another ploughing.

15.	December	7
16.	———	18
17.	———	26

THE PRODUCE.

Nº 1.	produced	4½ ounces.
2.		5½
3.		7
4.		7¼
5.		7½
6.		7½
7.		7¼
8.		7½
9.		6¼
10.		6¾
11.		6¼
12.		6
13.		5½

N° 14.	produced	5 ounces.
15.		$4\frac{1}{2}$
16.		4
17.		4

"We find in this table, that the principal produce is from N° 3 to 8, that is, from the 10th of September to the 18th of October; before and after which time we do not find any date with so considerable a one. The similarity of the produce of the dates, within that period, gives much reason to suppose an equality from the beginning to the end of it.— Number of ploughings are apparently of no effect in making up for too late a sowing: but whether that is really the case, cannot be absolutely known, as the product might otherwise have been lefs.

"Experiment VIII. p. 296.

"In 1765, marked some perches in the same field, on a clover lay that had been mown once, and part twice; the ploughings did not vary in this experiment. They were sown in the following seasons:

N° 1.	August	17
2.	———	26

Nº 3.	September	3
4.	———	10
5.	———	21
6.	———	28
7.	October	11
8.	———	18
9.	———	25
10.	November	2
11.	———	9
12.	———	16
13.	———	23
14.	———	30
15.	December	7
16.	———	18
17.	———	26

"Those numbers that were sown before the second crop of clover had come to a proper height for hay, were mown young, and the produce carried off. The hoeing and weeding were performed the same days to all.

THE PRODUCE.

Nº 1. produced	$3\frac{1}{4}$ ounces.
2.	$3\frac{3}{4}$
3.	5
4.	7

N° 5. producd	$8\frac{1}{2}$ ounces.
6.	$7\frac{1}{2}$
7.	7
8.	7
9.	7
10.	$6\frac{1}{2}$
11.	$6\frac{1}{4}$
12.	$6\frac{1}{2}$
13.	$5\frac{1}{2}$
14.	$5\frac{1}{2}$
15.	$4\frac{1}{2}$
16.	5
17.	$4\frac{3}{4}$

"This experiment, upon the whole, confirms the result of the preceding; which is of the more consequence, as it is a total variation, being a clover-land crop, and all the rest fallow ones. But the trifling product of the first numbers sown early, shows that very early sowing is vastly worse on clover than on fallow land; which I suppose, is owing to the roots of the clover not only being short of their proper size and growth. but also in an improper state for forwarding the growth of the wheat; perhaps so full of juices as to mould the seed.

EXPERIMENT IX. p. 297.

"In 1766, I marked several perches of fallow land, in the field of experiment V. and sowed them each with one ounce of seed as before, at the following seasons:

N° 1.	July	30
2.	August	4
3.	———	11
4.	———	18
A fresh ploughing.		
5.	August	25
6.	September	1
7.	———	8; heavy rain.
Another ploughing.		
8.	September	15
9.	———	22
10.	———	29
Another Ploughing.		
11.	October	7
12.	———	13
13.	———	20
14.	———	27
Another ploughing.		
15.	November	3
16.	———	13; heavy rain fell the 8th
17.	———	17
18.	———	24

Another ploughing.

Nº 19.	December	1
20.	——	8
21.	——	15
22.	——	22
23.	——	29
24.	January	29

; the severity of the weather prevented sowing sooner.

25.	February	7

Another ploughing.

26.	February	14
27.	——	21
28.	——	28
29.	March	7
30.	——	14

Another ploughing.

31.	March	28
32.	April	6
33.	——	13
34.	——	23

Another ploughing.

35.	April	28

"I should here remark, that the ploughings were never performed when the ground was in an improper state for the operation for a wheat sowing; respecting wet, I mean.

The hoeing and weeding were performed on the same days to all, except the spring sowings, which varied once.

THE PRODUCE.

N° 1 produced	3 ounces.
2	3½
3	3½
4	5
5	5½
6	7½
7	8
8	7¼
9	8
10	7½
11	7½
12	6¾
13	7
14	6½
15	6½
16	6½
17	6¼
18	6
19	5½
20	4¼
21	5
22	4½
23	4

N° 24	produced	$3\frac{1}{2}$ ounces.
25		$3\frac{1}{2}$
26		3
27		$3\frac{1}{2}$
28		3
29		3
30		$3\frac{1}{2}$
31		$3\frac{3}{4}$
32		$3\frac{1}{2}$
33		3
34		$2\frac{1}{2}$
35		3

"The result of this trial, I apprehend, is very important: the seasons, from first to last, are so extremely various, that the effect might easily be supposed to carry conclusions of consequence. The end of July, and the first fortnight in August, are evidently very improper seasons; the last fortnight better. From the 1st of September to the 20th of October, the prime season of the whole experiment: from the 27th of October to the 24th of November, the produce is not greatly inferior. The December sowings are much lower. Those of January, and all after, very low; not much difference between them. Now, it must be considered, that there are eight ploughings between the first and the last sown, and yet the produce of each is the same; and it is observable, that there appears much reason to think, that the ploughings have little, if any effect. The season appears to be the cause alone of variation: a point of great consequence for every farmer thoroughly to attend to. Early sowing (earlier than is common) is evidently advantageous; which should likewise be remarked, as a ploughing, or perhaps two, may be saved with profit—an object of much consequence to every husbandman.

"EXPERIMENT X. p. 300.

"In 1766, marked 35 perches, as in the preceding trials, and sowed them in the same days. The ploughings were all repeated at the same time; but a variation made in all, of manuring the land with rotten dung, at the rate of about twelve loads per acre; which was on all ploughed in by the earth preceding the sowing.

THE PRODUCE.

N° 1	produced	3 ounces.
2		3
3		3½

Nº 4	produced	6 ounces
5		$5\frac{1}{2}$
6		6
7		$7\frac{1}{2}$
8		8
9		$8\frac{1}{2}$
10		$8\frac{3}{4}$
11		$7\frac{1}{2}$
12		$7\frac{1}{4}$
13		$6\frac{3}{4}$
14		7
15		$7\frac{1}{4}$
16		7
17		$6\frac{1}{2}$
18		$6\frac{1}{2}$
19		$5\frac{3}{4}$
20		$5\frac{1}{2}$
21		$5\frac{1}{2}$
22		$5\frac{1}{4}$
23		$5\frac{1}{4}$
24		5
25		$4\frac{1}{2}$
26		$4\frac{1}{2}$
27		4
28		$3\frac{3}{4}$
29		3
30		3
31		$3\frac{1}{4}$

N° 32	produced	3 ounces.
33		3
34		2½
35		2

"The general result of this experiment seems to confirm the preceding one; only it is observable, that the manuring renders later autumnal sowing more beneficial than in the unmanured: and it is, I think, consistent with reason that this should be the case. The very early and very late sowings seem to be the worse for the dung.

Experiment XI. p. 301.

"In 1766, marked 35 perches of fallow in the field of experiment VII. and sowed them as before, on the same dates, and with the same ploughings as the two last inserted trials.

THE PRODUCE.

N° 1	produced	3¼ ounces.
2		3½
3		3½
4		6¼
5		5¾
6		6½

N° 7 produced	7 ounces.
8	7½
9	6¾
10	7½
11	7¼
12	7½
13	7½
14	7¾
15	6¾
16	7
17	7
18	7
19	6½
20	6½
21	5¾
22	6
23	6¼
24	5½
25	5¼
26	5
27	5¼
28	5
29	5
30	4¾
31	3¼
32	3½
33	3¼
34	3¼
35	3

"This experiment is a confirmation of most of the preceding. From September 8th to November 24th, is the chief produce; which agrees much with the result of former trials. Very late sowings, notwithstanding the increase of ploughings, are pernicious; and very early ones the same. There cannot be a greater proof of the importance of sowing at the proper season, than its more than balancing all the advantages of extra-tillage.

Experiment XII. p. 302.

"In 1766, marked 35 perches, and sowed them as before, on a clover lay, in the field of experiment VII. The dates the same as in the preceding trials.

THE PRODUCE.

N° 1 produced	2½ ounces.
2	3¼
3	3¼
4	4
5	5¼
6	5¾
7	8
8	8¼
9	7½

N° 10	produced	7½ ounces.
11		7
12		7¼
13		7
14		7
15		7
16		6¾
17		7
18		7
19		6¾
20		6½
21		6
22		6¼
23		5½
24		5
25		4¾
26		5
27		4½
28		4¼
29		4½
30		3½
31		3¼
32		3
33		3
34		2¾
35		2½

"From September 8th to December 22d,

is the season of the greatest produce: it lasts longer in this trial than in former ones, which must certainly be attributed, in part, to the soil being a gravel. The other dates are good or bad, in proportion to their being near or far removed from that period.

"GENERAL OBSERVATIONS.

"I must observe upon this series of experiments, that all were kept quite clean of weeds; which management occasioned a variation of expense, according to the variety of seasons.

"The early-sown corn required a thorough weeding before winter; in respect of tillage after sowing, this was all the difference in the expense, (ploughings excepted,) between sowing in July or August, and September or October. The common farmers' principal objection to early sowing was this point of weeds: "If," said they, "we were to sow "so early, our crops would be overrun with "weeds, and destroyed by them." But this would have been no objection to the practice, had it otherwise proved beneficial: for, upon a supposition that the fallow could not be freed so soon from weeds, yet the crop admits of the most exact cleansing. I have often had broad-cast crops thoroughly cleaned from all sorts of weeds by hand-work; and, by an earlier growth of them, such a work might be performed so much the easier: and, if such a system was not approved, that of hand-hoeing, with small three or four inch hoes, would effectually answer every objection.—Upon the whole, I may afsert from experience, that in broad-cast sowing the additional cleaning from weeds, arising from early sowing, will not, upon an average of several years, amount to above 5s. per acre, supposing the fallow to have been managed as it ought in common husbandry; viz. the tillage to begin in the autumn, or before: but, as to the execrable method of not beginning to plough till after barley-sowing, I certainly need not add that, with such a conduct, a very early-sown crop must stand a chance of being absolutely destroyed. And I should further observe, that these remarks are proportionably applicable to that season which these experiments show to be the most beneficial, viz. September, and the first fortnight in October; which is, upon the whole, a full month earlier than the Suffolk farmers venture their seed in the ground; consequently, any objections to that season, of this nature, are void of foundation.

"As to the dates of the time of sowing, it, upon the whole, appears decisively, that the month of September is the most advantageous; and next, with a slight inferiority, the first fortnight of October: succeeding months to April are all bad; the more remote the worse; and that notwithstanding all advantages of extra ploughings. This result is peculiarly important for giving much tillage to land; for a certain decrease of product proves it evidently a pernicious practice, and such as never could obtain, without the afsistance of false ideas.

"The common idea of this neighbourhood is, that a fortnight after old Michaelmas is the prime wheat-seed season; but these experiments, I apprehend, clearly prove the contrary.

"I never perceived any difference between the corn sown at different seasons, in respect of distempers, or being beaten down."—So far the ingenious Mr. Young.

Looking over the memoirs of the Laudable

Society of Berne for the year 1764, I was most agreeably entertained with M. de Saufsure's account of the time of sowing wheat. His experiments and reasoning upon them do honour to the most consummate philosopher. The length of time employed in this interesting part of rural economy, gives weight and solidity to his arguments. I think I cannot finish this efsay in a more useful manner, than by transcribing the sentiments of this most ingenious foreigner. The reader is desired to carry in his mind, as he goes along, a just idea of distinction between this kingdom and the country of Swifserland, where the experiments were made.

"On the 8th of August, 1740," says M. de Saufsure, to whom we owe these experiments, "I sowed a *coupe** of wheat in the middle of a field, which required three *coupes* to sow the whole of it, being of opinion that this might be a more favourable season for sowing that grain, than the time which is usually chosen for it. This opinion was founded on my having often heard say, that those crops were

* The *coupe* is a Swifs measure, nearly equal to two of our bushels.

the best which had taken good root before the winter; and this, I thought, must be most effectually brought about by sowing early.— The rest of this field was sown in the latter end of September, the usual time of sowing in this country, that I might the more easily compare the two methods. Every part of the field had received the same manure and the same tilth, and was sown with the same parcel of wheat.

"The peasants, who were witnefses of what I did, declared, that if the wheat did not remain a month in the ground without sprouting, it certainly would not yield any crop.— The succefs exceeded my hopes, and proved contrary to their prognostic.

"The wheat sown in the month of August was, at harvest, taller, thicker, and cleaner than the corn in the rest of the field. In general there was a great deal of smutty wheat that year. The sides of my small field were much infected therewith, but there was not one smutty ear in the middle of it. Here is a very efsential advantage of early sowing, which this experiment promises.

"The cleannefs of the sheaves of the first-sown wheat induced me to thresh them separately, and they yielded a good deal more corn than those which came off the rest of the field.

"I repeated the experiment the next year. On the same day, the 8th of August, I sowed two *coupes* and a half of wheat upon narrow ridges, and in a small field where the land lay flatter, and of which the soil was not all of equal goodneſs. The event was the same as before. The crop yielded eighty-five sheaves, seven feet in circumference at the binding of the sheaf. Twenty such sheaves give usually from four to five *coupes* of corn, more or leſs, according to the goodneſs of the soil and season. The sheaves of this experiment yielded, in general, about a quarter of a *coupe* each. One place, of about twenty square toises of eight feet, yielded six sheaves; a very great crop. These six sheaves had indeed leſs grain in them than the others. The corn was laid, and these sheaves yielded but an eighth part of a *coupe* each, which was, however, an increase of ten for one. The corn was not laid in any other part of the field, the strength of the stalks keeping it upright.

"From this time I continued to sow every year a little earlier and a little more, and always with the same succefs. In the year 1744, I sowed a field all of the same kind and soil, and ploughed into high ridges, each alternate ridge, one in August and the other in September. The crops were very different. The corn sown in August was taller and thicker than the other. They were each reaped apart, that I might the better compare their increase. Twenty sheaves of that sown in August yielded four *coupes* and three quarters. The same number of sheaves of the other yielded but three and three quarters, as is usual elsewhere in the country.

"I now looked upon this time of sowing as sufficiently confirmed by experience, and have continued the practice constantly, beginning to sow in the first week in August, and ending it as soon as pofsible. I compare my corn of every year with what is sown later, and constantly find the comparison is in favour of my method.

"In 1751, I found a remarkable difference between my crop and those of my neighbours. There was a great fall of snow that winter, and the thaw was followed by frequent and alternate frosts and thaws. My neighbours reaped only a few sheaves of corn, which grew where the ground was sheltered by hedges, and the snow lay longer; whilst on the whole of my sowing, I reaped fifteen sheaves for every *coupe* that was sown, and they yielded me three *coupes* of good wheat. This was indeed a small crop when considered by itself; but it was considerable when compared with the neighbouring no-crops, or nearly so. The superiority of my crop was owing, not only to my early sowing, but, I believe, also to my lands being laid in high ridges; the furrows carry off the melted snow before the returns of the frost.

" My neighbours began now to be sensible of the advantage of my practice, and I had the pleasure of seeing many of them begin to sow on the first of September, some even in the month of August. By degrees, their reason got the better of their prejudices.

" I make no scruple now to declare, after an experience of twenty-three years, that the best time for sowing wheat in this country (Swifserland) is the beginning, or at farthest the middle of August. I sow my heavy and my light lands at the same time, without any distinction. In the field on which I first began this practice, there is some light land, and some of it even mixed with gravel; yet there, as in every other soil, the early sowing has constantly succeeded.

" It is a common opinion, that if wheat goes into stalks before the winter, it perishes. This is a maxim which paſses from mouth to mouth, and is established by tradition, without ever making the experiment; for that would at once give it the lie. I can declare, that my wheat, sown in a good soil, constantly rises into stems, which have sometimes several knots, before the winter. They begin even to tiller; for I counted seven or eight stalks on one plant in the month of October. The wheat which I sowed on the 8th of August, 1741, was as much grown in the month of November, as it usually is in the latter end of April; yet it preserved its verdure and strength all the winter, which was not milder than common. There were some plants of rye which had gone into ear, and perished in the winter: yet they roſe again in the spring, the roots having remained entire.

" Some people are frightened at the yellow colour which the early-sown wheat is sometimes of at the end of the autumn. It has frequently happened to mine, but was not attended with any ill consequences. The cause of it seems to be the same with that which makes the leaves fall from trees. The juices which had hitherto risen in great plenty, stop in the winter. The same happens to grafs which withers, but the roots suffer not; on the contrary, perhaps they increase the more. The wheat sown later is lefs subject to this accident, because its blade require lefs juices to support them.

"I sow my wheat even in the greatest drought, which being frequent here in the month of August, would prevent my sowing was I to delay it on that account. My wheat, I think, makes a considerable progrefs during the dry season; and though that progrefs be not apparent, it is, perhaps, not the lefs real. There is at all times in well-ploughed grounds a moisture, if not sufficient to make the grain spring, at least enough to swell and prepare it. I have never found any inconvenience arise from it, and have thought that my crops, which came from corn that had lain a fortnight or three weeks in the earth, were better than when a wet season had brought them up sooner.

"The grain which has undergone this preparation, springs up on the first rain; whereas they who delay sowing till the rain comes, must also wait till the earth is again a little dried. This rain sometimes continues too long, and may prevent the wheat's being sown till winter, as happened this year to our neighbours in Savoy. They intended sowing their wheat in October. It was not drought that caused this delay. It was indolence in some, and proceeded in others from their having too great a quantity of land to plough in proportion to their cattle. However it was, a month or five weeks' rain prevented their sowing till November, and their corn now, in May, at the time of my writing this, looks very poorly.

"By beginning to sow early, I am never in danger of having my seed-time thrown back in this manner. It may perhaps be said, that a continued drought may prevent my corn's rising before the winter. The year 1746 showed me that I had nothing to fear from this inconvenience. The summer of that year was very hot and dry. I sowed my wheat in the beginning of August, in a very hot season, and in a strong soil, with a gentle declivity to the south; and as I sow under furrow, the grain was lodged pretty deep. The dry weather continued through the autumn, and the few showers that fell, did not penetrate deep enough to reach the grain. The winter was cold and dry till February. During all this time there was not a blade of my corn to be seen, except from a few grains which had fallen in the furrows. At length the rain fell plentifully in February, and the corn came up nearly as thick as if it had risen in due time. The stalks became large, and the ears looked well, but did not contain much grain, the time for its vegetation being too short.

" In the beginning of this practice, I was afraid that crops so superior to others might too much impoverish the land, which had not received any additional help, and thereby make it afterwards yield poorer crops. Full of these thoughts, after having reaped more plentiful crops from those parts of my field which were sown in August 1744, than from the rest, I sowed the whole field the next year at the same time, and was impatient to see the event. I saw, with surprise, that the same ridges had a shadow of superiority over the others. Whether this proceeded from the plants drawing a greater quantity of nourishment from the air before the late sowing had risen, and continued so to do by their larger surface; or whether the parts sown, being six weeks lefs time in fallow, had lost so much lefs by evaporation, I will not determine.—A similar observation is laid before us by the Sieur Grauque, of the mountain of Diefse.—Recommending a certain mixture of grain for spring sowing, he says that it is necefsary to get as great crops as pofsible, because, *the greater the crop the land bears, the lefs it is altered or impoverished by it*; and on the contrary, *the lefs the crop is, the poorer the land becomes.*

"We know that wheat sown late in November will bring a crop, and that more plentiful than what is sown in March: yet the progrefs which the former makes more than the latter, can be only in the roots; for the blades will soon be nearly the same in both. This is likewise the case in the several garden-plants, where the seed sown early gives a better crop than that of the same kind which is sown late. Trees also transplanted in autumn, thrive better than those planted in the spring; though to appearance, the juices remain inactive during that interval.

"On these principles it will be an easy matter to account for the advantages which the wheat sown in August has over that sown later. The greater quantity of nourishment which it collects, renders the straw stronger and bigger, and yields larger and better-filled ears. The grain itself is also larger. This I have found to be invariably the case in all the comparisons I have made.

"The strength of the straw is of great advantage in being able to withstand storms, which would otherwise lay it. The most fertile parts of my land give sometimes forty or forty-four sheaves for one *coupe* sown. The corn of this country, which is so thick as to yield that number of sheaves, is constantly laid by the first storm in June: mine stands till harvest, though sometimes bent in the middle, so that the ears hang down; but this does not in the least diminish the crop.— When the corn is exceedingly thick, as that in 1741, it will be laid. That has happened but seldom. In order to prevent this inconvenience, our farmers take quite the contrary method. They sow later, and say, that by this means the corn grows thinner, the straw is shorter, and the ears lighter. But surely it is much wiser to make sure of a crop by rendering it more fruitful, than, by lefsening it, to prevent the danger.

"I may ascribe to the same practice, the advantage I have enjoyed of having no smutty or otherwise diseased ears in my fields ever since I began to sow early; or at least but very few, when my neighbours have suffered thereby very much."

ESSAY XV.

On a Wine, called by the Tartars Koumiſs.

IN an age like the present, when few things in nature seem to have eluded the researches of philosophy, when the communications of learning are as well established as those of commerce, it may appear somewhat surprising, that one of the most important productions of milk should still remain, in a great measure, unknown to the most enlightened parts of Europe.

The production I mean is the vinous liquor which is procured by fermentation from mares milk. And it was scarcely to be expected, that, after it had escaped the observation of men the most skilled in chemistry, it should be taught us by a horde of Tartars, whose rank in society is not above that of barbarians.

Even in Rufsia itself, it was with difficulty I could learn the particulars of the preparation; and though it has been used, for some ages, by several tribes of people who belong to that empire, yet, in the year 1781, when I first began to think of employing it in medicine, it was as little known in what may be called *Rufsia proper*, as it is now in Great Britain. If the academicians of St. Petersburgh gave some accounts of it, these accounts have never excited the attention of the physicians of Rufsia.

This neglect is most probably to be ascribed, partly to the obscure relations of travellers, and partly to the pride of system, which men of learning are too often apt to indulge, in rejecting as incredible whatever does not coincide with their own pre-conceived opinions.

On consulting the authors who have made mention of this subject, I find, that they give little satisfactory information concerning it. They all agree, that a vinous liquor, from mares milk, was used by some of the Tartar nations, under the name of *Koumifs*; but none of them enter into a detail of the procefs by which that wine was prepared, much lefs does any one of them point out the purposes, either in economy or medicine, to which it may be applied.

Marcus Paulus Venetus gives some account of it in his History of the Eastern nations*; which was published as long ago as the thirteenth century. He says it was used by the Tartars as their common beverage, but makes no mention of the method of preparing it.

Strahlenberg, in his description of the Russian empire†, relates some circumstances of the preparation; but his method, if followed, could not be attended with succefs; for he mentions, that the Kalmucks take off the thick substance, which, in consequence of souring, rises to the top of the milk, and employ this in their food, while they use the remaining liquor either for drink or distillation. Now, this is not only contrary to the usage of that people, when they wish to obtain a fermented liquor of any strength; but experience proves, that no perfect fermentation can be produced, unlefs all the parts of the milk be left united in their natural proportion.

Gmelin, in his history of a tour which he

* De Region. Oriental. lib. 1. cap. 57.

† Beschreibung des Rufsichen Reichs, p. 319.

made through Siberia*, pays more attention to the Tartar method of distilling a spirit from the wine of milk, than to the fermenting procefs by which that wine is procured.

The latest writer that I find mentioning *Koumifs*, is the celebrated profefsor of natural history in St. Petersburgh, Dr. Pallas†. His account is as circumstantial as could well be expected from a traveller, whose object was natural history in general; yet the principles on which the fermentation depends, as well as the mode of conducting the procefs, are not sufficiently explained in his work.

These accounts, however imperfect, might have led philosophers, long before this time, to a discovery of the true method of fermenting milk, had not the writings of Newman‡, an eminent German chemist, contributed to deceive them. He was himself imposed upon by one Lucas, a Dominican monk, who ascribed its fermentation to the flour of millet

* Gmelin's Reifse durch Siberien, t. 1. p. 273.

† Physicalish. Reise durch einig. provintz. des Rufsisch. Reich, t. 1. p. 316.

‡ Newman, Chem. experimental. t. 1. part 2. p. 18.

and the grains of barley, which, he said, the Tartars added to it, and to the wine-cask in which the operation was performed. Newman, it would seem, was unwilling to admit of the fermentability of milk, because it was contrary to the ideas he had entertained of an animal liquor; and, therefore, adopting the opposite opinion, he seems glad to have an authority, however weak, to support it.

Voltelen*, too, a chemist of Holland, affords a striking example, how easily men are misled, even in matters of science, by their own prejudices. He had no doubt of the existence of a fermentable principle in milk, inasmuch as it contained a certain quantity of a saccharine substance. He knew also, that the whey contained the sugar in solution; it was on it, therefore, that he instituted his experiments; he added even more sugar to the whey than the natural proportion; but no vinous fermentation could, by any means, be produced in it. Nor did even his want of succefs undeceive him. He never once imagined, that the butyraceous and caseous

* Observat. de lacte humano cum asinino et ovillo comparato, p. 54.

parts of the milk were no lefs necefsary to its fermentation than the saccharine and serous.

Even Macquer, in his Chemical Dictionary*, has fallen into an error of the same kind.— Speaking of whey, he says, "In whey is con-"tained difsolved, a considerable quantity of "extractive substance, of the nature of the "saccharine juices, and it is accordingly sus-"ceptible of the spirituous fermentation.— "The Tartars certainly make from it a "spirituous drink, or kind of wine." From this it appears he had not made the experiment.

The following method of making *Koumifs*, is that which I adopted in my own practice with succefs. It is common among the *Baschkir Tartars*, who inhabit that part of the government of *Orenbourg* which lies between the rivers *Kama* and *Volga*. It was communicated to me by a Rufsian nobleman, in whose case I was consulted, and who was the first who made use of it by my advice. He went into that country on purpose to drink it; and, as he resided for some time there, he

* Macquer Dictionary of Chemistry, p. 432.

could not be mistaken with respect to the procefs.

Take of fresh mares milk, of one day, any quantity; add to it a sixth part of water, and pour the mixture into a wooden vefsel; use then, as a ferment, an eighth part of the sourest cow's milk that can be got; but, at any future preparation, a small portion of old *Koumifs* will better answer the purpose of souring; cover the vefsel with a thick cloth, and set it in a place of moderate warmth; leave it at rest twenty-four hours, at the end of which time, the milk will have become sour, and a thick substance will be gathered on the top; then, with a stick, made at the lower end in the manner of a churnstaff, beat it, till the thick substance abovementioned be blended intimately with the subjacent fluid: In this situation, leave it again at rest for twenty-four hours more; after which, pour it into a higher and narrower vefsel, resembling a churn, where the agitation must be repeated, as before, till the liquor appear to be perfectly homogeneous; and, in this state, it is called *Koumifs;* of which the taste ought to be a pleasant mixture of sweet and sour. Agitation must be employed every time before it be used.

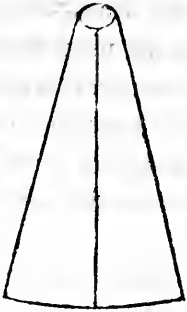
To this detail of the procefs, he subjoined, that in order to obtain milk in sufficient quantity, the Tartars have a custom of separating the foal from the mare during the day, and allowing it to suck during the night.—And, when the milk is to be taken from the mare, which is generally about five times a-day, they always produce the foal, on the supposition, that she yields her milk more copiously when it is present.

To the above method of making *Koumifs*, which I have translated as literally as pofsible from the original Rufsian manuscript now in my pofsefsion, I will add some particulars, taken from other communications with which I was favoured by Tartars themselves. For though I think no addition necefsary to render it either more simple or more intelligible, yet I think it my duty to withhold nothing which may, in any wise, throw light on so efsential a part of my subject.

According to the account of a Tartar who lived to the south-east of *Orenbourg*, the proportion of milk and souring ought to be the same as above; only, to prevent changing the vefsel, the milk may be put at once into a pretty high and narrow vefsel; and, in order to accelerate the fermentation, some warm milk may be added to it, and, if necefsary, more souring.

From a Tartar whom I met with at the fair of *Macarieff* upon the Volga, and from whom I purchased one of the leathern bags * which are used by the Kalmucks for the preparation

---



* This bag was made of a horse's hide undrefsed, and by having been smoked, had acquired a great degree of hardnefs. Its shape was conical, like the figure in the margin, but was at the same time, somewhat triangular, from being composed of three different pieces set in a circular base of the same hide. The sutures, which were made with tendons, were secured by a covering on the outside, with a doubling of the same skin, very closely secured. It had a dirty appearance, and a very disagreeable smell. On being asked the reason of this, he said, "The remains of the old *Koumifs* "were left, in order to supply a ferment to the new "milk."

and carriage of their *Koumifs*, I learned, that the procefs may be much shortened by heating the milk before the souring be added to it, and as soon as the parts begin to separate, and a thick substance to rise to the top, by agitating it every hour, or oftener. In this way, he made some in my presence in the space of twelve hours. I learned also, that it was common, among some Tartars, to prepare it in one day during summer, and that with only two or three agitations; but that in winter, when, from a deficiency of mares milk, they are obliged to add a great proportion of that of cows, more agitation and more time are necefsary. And though it is commonly used within a few days after the preparation, yet, when well secured in close vefsels, and kept in a cold place, that it may be preserved for three months, or even more, without any injury to its qualities.

He said farther, that the acid fermentation might be produced by sour milk, as above, by a sour paste of rye-flour, by the rennet of a lamb's stomach, or, what is more common, by a portion of old *Koumifs*; and that, in some places, they saved much time, by adding the new milk to a quantity of that already fermented, on being mixed with which, it very soon undergoes the vinous change It was according to the first procefs, however, that all the *Koumifs* which I have employed in medicine was prepared.

From all these accounts, it appears, that three things are efsential to the vinous fermentation of milk. These are *heat*, *souring*, and *agitation*. Heat is necefsary to every species of fermentation, and souring is perhaps not lefs so, though not in so sensible a degree as in the present case; but the chief art of fermenting milk consists in *agitation*. This last circumstance has wholly escaped the attention of chemists, notwithstanding it appears to be consonant to the operations of nature in other species of fermentation. In fermenting vegetable juices and infusions, nature has no need of the afsistance of art; the intestine motion which accompanies the fermentation is sufficient to produce the degree of agitation which seems necefsary to keep the parts of the fluid in mutual contact, or to fit them for mutual action. Milk, on the contrary, is no sooner soured than a separation of its parts takes place; the cream rises to the top, while the cheese either falls to the bottom, or is suspended in the whey. When these parts are brought, however, into close contact with one another, by agitation, and this repeated at proper intervals, a vinous liquor is produced; of the medical virtues of which I shall now treat.

From the time I had heard of *Koumifs*, I had conceived an opinion of its importance in the cure of certain diseases. I judged, that a preparation of milk, which could not be curdled by the juices of the stomach, while, at the same time, it pofsefsed all its nutritive qualities, with the superaddition of a fermented spirit, might be of efsential service in all those disorders where the body is defective either in nourishment or strength.

The case of the above mentioned nobleman, who communicated to me the first procefs, gave me an opportunity of trying, how far my conjectures were well founded. He was in that state which seemed to me strongly to indicate the use of such a medicine as *Koumifs*. I accordingly advised him to it.

At twenty-six years of age, he laboured under a complication of chronic complaints.

A confirmed *lues venerea*, injudiciously treated, with three succefsive salivations by mercury, added to bad management of himself under these, had given rise to his disease. His body was much emaciated; his face was of a livid yellow colour; his eyes were sunk, and round his eye-lids there was a dark shade; he felt a severe pain in his breast, and that was accompanied with a considerable cough and mucous expectoration; his appetite and digestion were greatly impaired; he had frequent tremblings and faintings; he began to feel the symptoms of hectic fever. In a word, his whole appearance was consumptive, and he was so weak that he required afsistance to get into the carriage in which he was to be conveyed into Tartary.

After drinking *Koumifs* six weeks only, he returned perfectly free from all the above symptoms, and was become so plump and fresh-coloured, that, at first sight, it was with difficulty his friends could recognise him. As he did not come immediately to *Nischne-Novogorod*, where I then was, he wrote me a letter, the substance of which, as far as it related to this subject, I shall give here.

After telling me the sudden and remarkable change the *Koumifs* had produced, during the first few days; that he ceased to be disturbed in his sleep; that his nervous and dyspeptic symptoms left him; that he felt as if his veſsels had been distended with a fresh cooling liquor; that he became cheerful; that it served him both for food and drink; that though he used it to the quantity of a gallon and a half, and sometimes even more, in the twenty-four hours, yet he always drank it with pleasure, and without intoxication; that his body, during its use, was regularly open; but that his urine was so much increased, that he was usually excited to make water every hour: He proceeded to expreſs himself in the following strong terms, which serves to show how much he had profited by it.

" I am disposed to consider *Koumifs*, (says " he) with all deference to you, as an universal " medicine, which will cure every disease, if " you do not choose to except fever; for I am " persuaded, that the most skilful physician, " with all the drugs of the shop, could not " have restored me to the health I now " enjoy"

The next case in which it was employed, though not so desperate as the former, gave sufficient proofs of its nutritive and strengthen-qualities, A lady, who had been witnefs to its uncommon efficacy in the nobleman's case abovementioned, was encouraged to try it in her own. It was not convenient for her to go herself to Tartary, and therefore she had it sent to her, well secured in casks, during the autumn.

She had been long subject to a train of nervous disorders. By these, she was much extenuated, and reduced to a state of extreme weaknefs and irritability. She used it for about a month, at the end of which time, the functions of her nervous system were restored, and, with health and vigour, she acquired a plumpnefs and fresh complexion.

The following year, I resolved to try it at *Nischne-Novogorod* under my own eye. As mares milk could not be obtained in sufficient quantity in town, it was made at the seat of a nobleman, not far distant, from which it was occasionally transported. The season was far advanced, however, before a case was presented, in which its efficacy might be tried. At last, about the middle of August 1782, I was consulted by the General Governor's nephew. He had all the symptoms of incipient phthisis; pain of breast, dry cough, occasional hæmoptysis, and great emaciation; he was not, however, become hectic. His two elder brothers had died of true pulmonary consumptions. He had taken much medicine, in a different part of the country, and had observed a very strict antiphlogistic regimen; but though milk had constituted the greatest part of his diet, yet there were no signs of recovery. He drank *Koumiſs* for about two months only, and that in rather an unfavourable season; but the consequence was, that all the above symptoms disappeared, and his flesh and strength returned; nor was there any reason to apprehend a relapse, at the time I left that country.

About the same time I advised its use to another yonng nobleman, who had laboured under an abscefs in the left side, about the region of the twelfth rib. As he had then resided in a remote part of the country, no attention had been paid to it; on the contrary, by improper applications, the sides of the ulcer were become hard. He had lost his flesh and strength; he had occasional faintings; and there were all the appearances of incipient hectic. By the use of *Koumifs* for about six weeks, proper chirurgical drefsings being at the same time applied, his health was perfectly re-established.

There was some other cases in which I employed it with equal succefs; but of which, as being lefs important, I omit the detail.

All those who drank it agreed in saying, that, during its use, they had little appetite for food; that they drank it in very large quantities, not only without disgust, but with pleasure; that it rendered their veins turgid, without producing languor; that, on the contrary, they soon acquired from it an uncommon degree of sprightlinefs and vivacity; that even in cases of some excefs, it was not followed by indigestion, headach, or any of the symptoms which usually attend the abuse of other fermented liquors. To this may be added, that the Baschkir Tartars, who, towards the end of winter, are much emaciated, no sooner return in summer to the use of *Koumifs*, than they become strong and fat*.

* The author of a historical description of all the nations which compose the Rufsian empire, says, speaking of *Koumifs*, " Elle est fort nourifsante, et peut tenir lieu

From all these circumstances, I think myself entitled to infer, that this wine of mares milk may be applied to many of the purposes of medicine. From the mild acid which it contains, may it not be considered as a cooling antiseptic? From its vinous spirit, may it not become an useful stimulant, cordial, and tonic? And, from its oily and mucilaginous parts, may it not prove a valuable article of nourishment? If chronic diseases, as is generally allowed, depend on a debility of the solids; and if they are difficult of cure, because the organs, which ought to supply the body with nourishment and strength, do not only themselves partake of the general weaknefs, but are too often, by the indigestible nature of the food with which they are overcharged, still more debilitated; may not a substance of easy digestion, which at once strengthens the stomach and nourishes the body, become a powerful remedy in all such cases?

And if acute diseases, especially of the

"de tout autre aliment. Les Baschkirs s'en trouvent "très bien, elle les rend bienportans et gais; elle leur "donne de l'embonpoint, et de bonnes couleurs."—*Descrip. de tout. les Nat. de l'Emp. Rufs. t.* 2. *p.* 118.

febrile kind, are frequently attended with symptoms of weaknefs and putridity, may it not be found, from its antiseptic and tonic powers, to be an useful corrector of the one, and a restorative for the other?

May not the sudden change it produced, in the *first* case, in the state of the patient's feelings, and especially of his sleep, point it out as of use in all cases of excefsive irritability?

May not the effect it had in restoring his stomach to its functions, recommend it in dyspepsia? and may not the vigour and plumpnefs which ensued from its use, indicate it in cases even of confirmed atrophy?

Have we not reason to believe, that it may be used to advantage in the cure of nervous disorders in general, from the manner in which it operated in the *second* case? And in the incipient, perhaps even in the advanced stages of phthisis, from the rapid and effectual change it occasioned in the pulmonary symptoms of the *third?*

And may not its efficacy in the *fourth* case, encourage us to employ it in all cases of suppuration or ulcer, in which the body is threatened with hectic fever?

Whether all these questions can be answered in the affirmative, must be determined by future experience; and, if they should, perhaps the scarcity of mares milk in this country would greatly circumscribe its utility.

Hence inquiries will naturally be made, whether other species of milk admit of a similar vinous fermentation, and what proportion of spirit they contain. As these have never been the object, however, of my attention, I will here give the substance of what I have been able to learn from others respecting that which is the most common, the milk of cows.

Dr. Pallas*, in the work above quoted, says, that cows milk is also susceptible of the vinous fermentation, and that the Tartars prepare a wine from it in winter, when mares milk fails them; that the wine prepared from cows

---

* Physicalisch. Reife durch verschied. provintz. des Rufsisch. Reichs, t. 1. p. 316. et 317.

milk, they call *Airen;* but that they always prefer *Koumiſs* when it can be got, as it is more agreeable, and contains a greater quantity of spirit; that *Koumiſs* on distillation yields of a weak spirit one-third, but that *Airen* yields only two-ninth parts of its whole quantity; which spirit they call *Arika.*

This account is confirmed by Oseretskowsky, a Ruſsian* who accompanied Lepechin, and other academicians, in their travels through Siberia and Tartary. He published lately a Diſsertation on the ardent spirit to be obtained from cows milk.

From his experiments, it appears, that cows milk may be fermented with, or even without, souring, provided sufficient time and agitation be employed; that no spirit could be produced from any one of its constituent parts taken separately, nor from any two of them, unleſs inasmuch as they were mixed with some part of the third; that the milk, with all its parts in their natural proportion, was the most productive of it; that the closer it

* Specim. inaug. de Spir. Ardent. ex lact. Bub. Argentorat. 1778.

was kept, or, which is the same thing, the more difficultly the fixed air is allowed to escape during the fermentation, (care being taken, however, that we do not endanger the bursting of the veſsel,) the more spirit is obtained. He also informs us, that it had a sourer smell before than after agitation; that the quantity of spirit was increased, by allowing the fermented liquor to repose for some time before distillation; that from six pints of milk, fermented in a close veſsel, and thus set to repose, he obtained three ounces of ardent spirit, of which one was consumed in burning; but that from the same quantity of the same milk, fermented in an open veſsel, he could scarcely obtain one ounce.

These particulars of the fermentation of mares and cows milk are an interesting addition to the facts concerning fermentation in general; a subject so very obscure and imperfectly understood, that I shall not hazard any remarks on it. My principal intention was, to point out to physicians what appears to me a powerful means which may be employed by them on many occasions in the cure of diseases.

ESSAY XVI.

On the Connection between Botany and Agriculture.

THE justly celebrated Linnæus, in his Amænitates Academicæ, has traced out the dependence which Agriculture has upon Botany, in a very masterly manner. He wishes the farmer to revive that old useful custom of observing the times of budding, leafing, and flowering of plants and trees, because these appearances seem to have been designed by Providence as our surest guides in conducting rural matters. They ascertain the exact times for sowing, planting, and reaping. They are the best thermometers (if I may be allowed the expreſsion) which we can use, after they have been regulated and confirmed by experience.

If we look into the annals of history we may remark, that many nations have observed certain periods for sowing, planting, and reaping, confirmed by the appearance of leaves on particular trees, or the migration of birds, which almost invariably corresponds with the leafing of those trees.

There seems nothing unreasonable in supposing the vegetable and animal world an excellent lefson to the rational. In the sacred history we are told, that the *Stork in the heavens knoweth her appointed times; and the turtle, and the crane, and the swallow, observe the time of their coming;* and we are reminded that the leafing of the fig-tree usually determines the approach of summer.

It is curious to see how steadily the antients have adhered to these principles. Theophrastus, that parent of natural knowledge! has left us many remarks of this kind, which Hesiod has much improved. But no one, since Hesiod's time, considered the matter in its proper light, till the great Linnæus started forth to be nature's more refined historian.

Among other things, Hesiod says, "That if it should happen to rain three days when the cuckoo sings, then late sowing will be as good as early sowing. That when snails begin to creep out of their holes, and climb up the plants, you must leave off digging about the vines, and take to pruning. That when the crane is heard, the time of ploughing comes on."

Dr. Linnæus observes that, in Sweden, the "wood anemone blows from the arrival of the swallow, and that the marſh marigold blows when the cuckoo sings. That barley is sown when the birch tree leafs."

These are sufficient proofs to convince us, that if the improvers of agriculture considered botany as a neceſsary illustration of it, we should be likely to advance our discoveries still higher in the scale of perfection. Indeed, to do justice to the present age, our improvements in agriculture seem to be built more firmly upon the foundation of philosophy and natural knowledge; a mode of proceeding which will undoubtedly be productive of the most pleasing consequences. For, by taking nature as a guide, the farmer may adjust his times of sowing and reaping with more certainty. He may frequently insure a good crop, by keeping his seed in the granary, till nature has pointed out a proper time for sowing it.

In Sweden, the study of Agriculture is much in fashion. And I date the æra of those refined improvements from the time that Linnæus held out his discoveries to public view. He has himself made observations of these kinds in every country he examined. And he gives us a list of a great number of different persons he employed to communicate to him the result of similar experience. The only experiment of this kind made in England, is by the ingenious Mr. Stillingfleet, at Stratton, in Norfolk, in the year 1755.

If we would derive any benefit from these kalendars of Flora, they should be made in every material variation of latitude, and should be made for three or four years at the least; that the forwardneſs or backwardneſs of some chance seasons might still be considered as exceptions only to a general rule. With these helps, I can scarcely imagine the farmer ignorant of the time of budding, leafing, flowering, sowing, and reaping of any individual plant or graſs in the whole extensive field of nature.

Some general knowledge of astronomy might likewiſe be of use in farther confirming these periods for sowing and planting. It is beyond a doubt, that the ancient husbandmen esteemed their practice not complete without it. Virgil begins his Georgics with the same thought:

> Quid faciat lætas segetes; quo sidere terram
> Vertere, Mæcenas, ulmisque adjungere vites,
> Conveniat: ——
> Hinc canere incipiam. ——

Another grand use of botanical knowledge to the farmer, would terminate in this point: That as a kalendar of Flora would acquaint him with the duration and existence of most plants; so he would be better able, in general, to suit the produce to the nature of his soil.

It is a just matter of wonder in this improving age, that so little attention should be paid to the laying down our meadow and pasture grounds. The quantity of land that is annually laid down makes an attention to this branch of rural economy efsentially necefsary. Every farmer knows how to suit his grain to the quality of his soil, but few are acquainted with the nature and disposition of the grafses that cover the field. The surface of the earth is clothed with a pleasing and necefsary variety of grafses. Some delight in a moist soil; others prefer a dry situation; and yet so little do we observe this order of nature, that grafs-seeds of all kinds, good and bad, are promiscuously sown upon the same soil. A small degree of reflection will teach us that vegetables, as well as animals, have a choice of soil. Therefore to stock our warm and dry lands with seeds produced upon wet meadows, is no lefs absurd than if the farmer was to bring down his sheep into the marshes, and send his bullocks to the hills.

Of late there has been much encouragement given to the collecting grafses by hand. It is here that the botanist becomes useful to the farmer. He knows from his kalendar of of Flora what plants blow together, and if a a mixture is required, can tell what species will render that mixture agreeable. For this useful purpose a small degree of botanical knowledge is required. Nature is ever constant and uniform with herself. She points out to us the plants peculiar to every soil, if we could be prevailed upon to trace her along the walk she delights to tread.

It is not an unusual thing to see a piece of excellent land over-run with wild ranunculus and coarse grafses. In that state it cannot maintain a stock in proportion to the goodnefs of the soil. Other lands of a much worse quality, by being laid down with a more judicious choice of seeds, are found to produce larger and more profitable crops of grafs. This consideration ought to awaken the attention of the farmer to a more skilful method of laying down his lands.

In the present situation of things, the farmer is liable to the imposition of the seedsman.— If he purchases the seeds of weeds, he must expect a plentiful crop of them in return for the painful care that he has taken of his lands. This inconvenience, however, may, in some degree, be removed by the help of botanical knowledge. Let the farmer examine the seeds well before he buys them. If he has made himself conversant with the shape and appearance of the seeds of natural and good grafses, and also of the seeds of such weeds as infest the meadows, he will find it easy and familiar to determine the goodnefs of the sample shown him. Nay, he may discover with certainty whether the seeds grew upon a wet or dry soil, and consequently may avoid the mischief that arises from not suiting the seeds to the nature of the soil.

It is not only curious, but necefsary, for the practical farmer to be able to find out the natural taste of his cattle. Of this he may soon make himself acquainted, without entering deeply into the science of botany. Cows, horses, and sheep, all differ in their tastes, and are more partial to one sort of grafs than another. And no wonder, when every plant delights in its proper soil; nay, every insect has its own peculiar plant to feed upon.

Linnæus reckons up above two thousand experiments, made by himself and his friends, on the tastes of animals. He gives us tables not only of the number of plants each animal eats or refuses, but the names of the plants themselves. The former may be grateful to the reader, but the latter would not conveniently come within the compafs of this efsay.

Oxen eat	276	refuse	218 plants.
Goats -	449	- -	126
Sheep -	387	- -	141
Horses -	262	- -	212
Swine -	72	- -	171
	1446		868

If this plan was pursued, we should not hear the farmer so often complain that his pastures are overrun with rough barren grafses, which the cattle will not eat. In most pastures we do not observe above half of the grafs eaten. The fact is this, that from neglecting the material point of suiting the palates of our cattle, grafses odious to the taste, and barren in themselves, overrun and destroy the good.

It would both be superfluous, and extending this efsay to a tedious length, to reckon up such grafses as are barren in themselves. But the following are the most prevalent in our meadow and pasture grounds. The carex tribe chiefly infest the moist parts of our meadows. The bent and hard meadow grafses overrun both meadow and pasture grounds. The mat-grafs is injurious to sheep-walks. And the quick-grafs is troublesome to the farmer in the extreme.

ESSAY XVII.

On the Nature and Properties of Marl.

IN many parts of this island the value of land has of late been greatly raised by the application of marl. It is divided into shell-marl and earth-marl Shell-marl is composed of animal shells difsolved. Earth-marl is a fofsil. Its colour is various; white, black, blue, red.—Its hardnefs is as various as its colour; sometimes it is soft and ductile like clay; sometimes it is hard and solid like stone; and sometimes it is extended into thin beds like slate. Shell-marl is easily distinguished by the shells which always appear in it. But the similarity betwixt earth-marl and many other fofsil fubstances, renders it difficult to distinguish them.

Marls, like all the subjects of the mineral kingdom, differ in their degrees of purity.—But how to discover, with certainty, the purity of any given marl, is not generally known.

From these circumstances we must conclude, that marl, though a substance of inestimable value, hath scarce ever been the subject of an attentive inquiry.

In this efsay it is proposed, first to analyse the different marls, as newly dug from the ground; and afterwards to examine what changes they suffer from being exposed to the air.

SECTION I.

The most known properties of marl are, its effervescing with acids and fertilizing the soil to which it is applied*. By these two pro-

---

* Dr. Hill, in his volume upon Fofsils, has ranked among marls many substances which do not effervesce with acids. But I cannot see by what reason such an arrangement can be justified. Perhaps all the substances which we find in the clafs of marls have, with advantage been employed in agriculture. But that is not sufficient. We know that pure clay itself, applied to certain soils, produces the most happy effects. All Dr. Hill's non-effervescent marls are pofsefsed of the distinguishing properties of clay: and therefore ought in justice to be ranked among the argillaceous bodies. After comparing this author's definition of marl with his definition of clay and bole, I can fix upon no particular

perties I was directed in the prosecution of my inquiry.

Among the subjects of the mineral kingdom, some are soluble in water, some not.— Of the first, one only, the fofsil alkali, is pofsefsed of properties similar in any degree to those of marl. For this salt, which is collected principally along the coasts of the Mediterranean sea, effervesces violently with acids, and has been time immemorial, in the highest esteem as a manure. From these circumstances it might be suspected, that a very intimate affinity subsists betwixt this alkali and marl, and that the similar effects of both these substances proceed from the same cause. To satisfy myself with regard to this particular, I made the two following experiments.

---

character by which the first of these substances may, with certainty, be distinguished from the other two. Marl seems, by his definition, to differ from clay and bole in degree of viscidity only. But how shall the degree of viscidity which constitutes a clay, or a marl, or a bole, be ascertained? A very considerable number of earth-marls are of a stony hardnefs; but all marls, by Dr. Hill's definition, cohere slightly.

Experiment I.

Two drachms of clay-marl, newly dug from the pit, were put into an ounce of water, and for twelve hours digested with a considerable heat. The marl, when separated by filtration and dried, retained precisely its orginal weight. The digested water was devoid of taste and smell, and suffered no change from the addition of syrup of violets, or the acid of nitre. The event was in every respect the same, when a quantity of the same marl was boiled in water for a considerable time.— Many varieties of clay, stone, and slate marls were treated in the same manner, with the same appearances.

II.

Two drachms of newly dug shell-marl, free from mofs, fragments of putrid wood, &c. and previously dried, were digested as in the first experiment. The marl neither lost any of its original weight, nor communicated to the water any thing discoverable by the trials mentioned above. The appearances were the same when this marl was boiled in water*.

* Caution is here necefsary. Shell-marl not only contains many separate fragments of putrid wood, but is

From these experiments it is evident, that no salt, similar to the fofsil alkali, is contained in marl. For all natural salts, of an alkaline quality, are distinguished by their easy solubility in water, by effervescing with acids in the same manner when difsolved, as before solution, and by converting the colour of blue or purple vegetable infusions into green.—But marl, neither when digested, nor when boiled in water, communicates any of its substance to that fluid; therefore contains nothing soluble by it, nor any salt of an alkaline, or any other nature. Besides, none of the waters filtered from the marls in the preceding experiments, suffered any change from the instillation of the nitrous acid, or of the syrup of

---

also very commonly mixed with parts of the mofsy stratum, under which it is generally found. If marl, containing either of these substances, is employed in the preceding experiment, it never fails to communicate a bitternefs and peculiar smell to the water. Besides these properties, this water, upon the addition of any alkaline solution, acquires a milky hue, and lets fall a small quantity of a white powder. That these effects proceed solely from the heterogeneous bodies mixed with the marl, is evident from this, that shell-marl when perfectly pure, and freed by evaporation from mofsy water, never communicates any perceptible quality to water in which it is digested.

violets. From these circumstances it is manifest, that marl does not contain the smallest proportion of an alkaline salt. And, as no other salt will account for the phænomena, this, added to some particulars mentioned above, renders any farther search for a saline substance in marl unnecefsary.

SECTION II.

Being satisfied with regard to this particular, the affinity betwixt calcarious earths and marl next occurred to me. Calcarious earths effervesce with acids, are remarkable for their fertilizing properties, and cannot, in a natural state, be difsolved by water. So far they agree exactly with marl. But their most characteristical qualities are, their difsolving entirely in the mineral acids, and calcining to quick-lime. By these two properties such earths may be distinguished wherever they occur.

With a view to the apparent affinity betwixt calcarious earths and marl, I made the following experiments.

Experiment III.

To a drachm of newly-dug stone-marl, reduced to powder, I gradually added the muriatic acid, till no further effervescence ensued upon the addition. This mixture, diluted with a sufficient quantity of water, was thrown into a filter of grey paper: A pure pellucid liquor paſsed through, and a groſs earthy substance remained behind at the bottom of the filter. This substance, when properly washed and dried, weighed just eighteen grains.

In this experiment, we find the marl divided into two different parts; the one carried off by the muriatic acid, and invisibly suspended in it; the other an earthy substance, on which that acid seems to have no influence. Having advanced thus far in the de-composition of our subject, the next step is to examine into the nature of these two constituent parts.

SECTION III.

Experiment IV.

The substance which remained in the filter, poſseſsed, almost in every respect, the properties of clay. In drying, it concreted into a maſs of considerable hardneſs; made no effervescence with any of the acids; fell down and diffused readily in water; and was, by the action of fire, converted into a reddish-coloured brick. Twenty grains of such a substance, extracted from the same marl, gave, by elutriation *, five grains of sand. Hence the nature of the unsoluble part of this marl is abundantly evident.

It must be remarked, however, that neither the quantity nor composition of this unsoluble part is, in any two marls, precisely the same. Clay, or clay and sand, are, it is true, the constituent parts of it in all marls †; but the different proportions, in which these are mixed with the soluble part, are almost infinite.

V.

The residue of a drachm of clay-marl, which was easily diffusible in water, weighed forty grains, and consisted of equal portions of clay and fine sand.

---

* This term is applied to the separation of clay from sand by means of water.

† It must be observed, that the residue of all or most marls contains, besides clay and sand, a considerable number of flat shining particles. These particles are unsoluble in acids, as is evident from their remaining in the residue. Few of them suffer any diminution of lustre in the fire. Whence they appear to be flakes of foliaceous talc.

VI.

A drachm of another clay-marl contained fifteen grains of unsoluble matter, which was altogether clay.

VII.

Forty grains of a smooth laminated marl afforded eight grains of a clay *residuum*.

VIII.

The residue of forty grains of a stone-marl weighed twelve grains, a third of which was sand.

IX.

A drachm of another stone-marl gave only nine grains of unsoluble matter, mostly clay.

X.

The residue of forty grains of another stone-marl * weighed sixteen grains, thirteen of which were sand.

* I have here given the name of marl to some substances which perhaps, in strict language, ought to go under another denomination; but they are generally accounted marls, and employed as such indiscriminately with the marly *strata* contiguous to them.

XI.

A drachm of a friable slate-marl afforded a *residuum* of eighteen grains of yellow sand.

XII.

A drachm of lime stone contained twelve grains of unsoluble matter, which was altogether sand.

XIII.

A drachm of another limestone gave only six grains of residue, which appeared to be a slime.

XIV.

A drachm of shell-marl, dug out at the depth of two feet from the surface, contained thirty-six grains of unsoluble matter, which acquired little cohesion by drying, and consisted in a great measure of a very fine sand.

These are the most remarkable differences that have hitherto occurred to me in examining the *residua* of different marls. I thought it necefsary to give a detail of them, both because the composition of the unsoluble part of our subject is thereby demonstrated, and because the preceding experiments will afterwards serve to explain a difficulty which would not otherwise admit of an easy solution.

SECTION IV.

We must now return to the pellucid liquor which pafsed through the filter in Experiment III. As this liquor contains, in an invisible state, the substance which, in combination with the part examined in Section III. composed the original marl, if we can discover the nature of that substance, the nature and composition of marl will of consequence be evident.

An alkaline salt, added to the solution of any other substance in an acid liquor, instantly precipitates that substance. The part of the marl difsolved and carried off by the muriatic acid in Experiment III. had no affinity to an alkaline salt *; therefore a salt of this nature, added to that solution, cannot fail to separate from it the soluble part of our subject, and consequently to give us an opportunity of examining it to greater advantage.

Experiment XV.

With this view, the fore-mentioned filtered

* See Expet. I. II.

liquor was mixed with a small quantity of a solution of salt of tartar. The mixture became immediately milky and turbid; but in a short time recovered its transparency by the copious precipitation of a whitish powder. More of the alkaline solution was then added; and as a new lactescency and precipitation ensued, the addition was from time to time repeated, till it produced no such effect. Then it was evident, that whatever the acid had carried off from the marl, was now thrown to the bottom. The precipitated powder, when separated by filtration, washed and dried, weighed precisely forty-two grains; which, added to the eighteen grains of unsoluble matter in Experiment III. makes up the original weight of the marl employed in that experiment. This powder was altogether insipid; suffered no change from water; and was, after a very brisk effervescence, totally difsolved both by the acid of nitre and of sea salt.

The liquors filtered off from the unsoluble matters in all the experiments related in Section III. were separately treated in the manner described above, and in every respect with the same appearances: Particularly the weight of each of the precipitated powders, added to that of its respective residue, equalled, with remarkable exactnefs, the original weight of the marl from which it had been extracted.

SECTION V.

These precipitated powders are totally soluble in acid spirits ; for it was by this solution that we obtained their separation from the other parts of the marls in which they existed. The knowledge of this single property, however, is not sufficient to determine their nature. The changes produced upon them by the action of fire must be also considered.

Experiment XVI.

For this purpose seventy grains of powder, extracted, in the manner described above, from the marl of Experiment III. were for two hours detained in a strong fire. The weight of the powder was thereby reduced to forty grains, and its colour from white changed to grey or ashy. When water was poured upon this calcined substance, many air-bubbles rose to the surface with a hifsing noise, and as strong a lime-water was in a short time produced as I had ever obtained from any quick-lime.

The calcination of the powders extracted from the other marls was attended, in every circumstance, with the same succefs; that from shell-marl not excepted.

From these experiments, I think, the nature of marl is sufficiently evident *. Marl consists of two parts, pofsefsed of very opposite qualities. The one, clay, or a mixture of clay and sand; the other, a substance soluble in acids, convertible by calcination into quick-lime, and consequently a real calcarious earth, differing in no respect from the calcarious earth of lime-stone and the shells of animals †.

* Here it may be asked, if such is the composition of all earth-marls, whence comes it, that some earths of that kind, or what strongly resembles them, are so destruciive to the growth of vegetables? In answer to this it must be remarked, that many fofsils, differing widely in their nature from marl, have frequently, from resemblance, been employed as marl. Among the fofsils of this country, is oft-times found a species of the Pyrites, *Lapis atramentosus* of Cramer, which in colour nearly ressmbles some of the earth-marls. I have seen a bed of this which contained a considerable proportion of calcarious earth. It may occur among beds of marl; but, whenever it is employed in agriculture, its effects must be unfavourable.

† The very efsence of marl seems to consist in this earth; for that name is bestowed on no substance that does not contain an earth of this nature. However all bodies, into whose composition calcarious earth enters, do not fall under the denomination of marl. To entitle

From the foregoing experiments it is also manifest, that the nature of clay-marls, stone-marls, and slate-marls, is altogether the same. For marls of equal purity, and consisting of the same proportions of constituent earths, are found under all these different appearances. Different names have been affixed to them, from their different degrees of hardnefs, and the different dispositions of the beds into which they are extended. But from what cause proceeds the diversity in the cohesive power of marls, equal in the proportions of their constituent parts, is difficult to say.

It appears from the experiments related in Section III. that, in different marls, the proportion of the calcarious to the other earths is not always the same. As this diversity may probably render a choice of marls for particular soils, if not necefsary, at least beneficial, a more minute account than that formerly given, of the procefs for discovering the proportion of earths contained in any marl, may not be improper.

---

them to this, they must fall into powder upon being exposed to the air. Hence, the purity of marls will be in proportion to the quantity of calcarious earth in their composition.

Having dried and powdered the marl to be examined, pour upon any given weight of it a small quantity of water. To this mixture, well shaken, add a little of the acid of sea salt*, and when the consequent effervescence is over, add a little more. Repeat this addition at proper intervals till no more effervescence ensues. Then throw the whole, with an equal or greater proportion of water, into a filter of grey paper, whose weight is known. When all the fluid parts have pafsed through, fill up the filter, again and again, with warm water. By this means the difsolved particles of calcarious earth, adhering to the residue, or entangled in the pores of the paper, will be washed away, and nothing but what is really unsoluble will remain in the filter. This *residuum* with the filter must be completely

---

* Any mineral acid may be employed with equal advantage, the vitriolic excepted. For, though this acid effervesces violently with all marls, it does not difsolve their calcarious earths; it only forms with them a whitish coagulum, which will not pafs through the filter. In any trials that I have hitherto made with the vegetable acid, I have not been able by its means to extract all the calcarious earth contained in any marl. For, after the usual filtration, the *residuum* always effervesced violently with the mineral acids.

dried and weighed. Then the difference betwixt its weight, and the original weight of the filter, gives you the weight of unsoluble parts contained in the marl under examination. This being known, the proportion of calcarious earth in the same marl is evident. The proportions of clay and sand in it are discovered by subjecting the *residuum* to a proper elutriation. This operation is very simple, and performed thus: Having weighed the dry residue, mix and shake it well with a sufficient quantity of water. After allowing a little time for the subsidence of the grofser parts, let the water, with the finest particles of clay suspended in it, be gently poured off. When this is done, add more water to the remainder, and, after sufficient mixture and subsidence, pour that off likewise. In the same manner repeat the operation, again and again, till the water comes over perfectly pure. The substance which then remains is sand, mixed, perhaps, with some flakes of talc; and whatever this substance wants of the weight of the residue employed, is the weight of pure clay carried away by the water in the procefs of elutriation.

It may be here observed, that the effervescence ensuing upon the application of acids to marl, cannot be relied upon as a certain indication of the quantity of calcarious earth contained in such substances. Numerous instances of the truth of this aſsertion have occurred to me. For the effervescence varies, both in violence and duration, according to the strength of the acid employed; but it varies still more according to the penetrability and other more secret circumstances of the calcarious bodies.

SECTION VI.

I next examined what effects fire would produce upon marl in its natural state. As many marls contain a very considerable proportion of calcarious earth, I expected that nearly the same changes would be produced upon them by calcination, as upon lime-stone.

Experiment XVII.

A piece of the marl of Experiment III. weighing eighty grains, was kept in a strong fire for two hours. Its weight was thereby reduced to fifty-two grains, and its colour, from a blueish white, changed to a reddish brown. Its hardneſs was at the ſame time considerably augmented; and though, when immersed in its natural state into water, it gradually relented and fell down into powder; yet now it neither suffered any change from that fluid, nor communicated to it any thing perceptible by the sight, taste, or smell. Notwithstanding this, when it was reduced to powder *, it afforded, upon the affusion of water, as pungent lime-water as any quick-lime could do.

XVIII.

The marl of Experiment VI. by burning loſt near a third of its weight, and acquired a very remarkable hardneſs. When put into water in this state, it did not relent in the smallest degree, though naturally it diſsolved readily in it. The laminated marl of Experiment VII. suffered precisely the same changes from burning.

* The pulverization of all burnt marls, that contain any considerable proportion of clay, is absolutely neceſsary to extract a lime-water from them. Inattention to this circumstance has, I believe, produced some mistakes. When shell-marl is burnt, pulverization is seldom requisite; because this substance being naturally of a loose and spungy texture, and acquiring little cohesion in the fire, allows the water an easy acceſs to its calcarious earth.

XIX.

The marl of Experiment VIII. when burnt and thrown into water, did not fall freely into powder, but loosened into pieces, which easily yielded to the presfure of the finger. This marl, before burning, difsolved very slowly in water.

XX.

The marls of Experiment IX. X. XI. suffered, in their natural state, scarce any perceptible change from water; but, when sufficiently burnt, they swelled and fell down in water like lime-stone.

XXI.

A drachm of shell-marl, Experiment XIV. was, by burning, reduced to forty-two grains, and then spontaneously yielded a strong lime-water.

From these experiments it appears, that the calcarious earth of marl is equally calcinable to quick-lime, whether it is exposed to the action of fire before or after its separation from the other earths.

It is now sufficiently evident, that the nature of marl * has a very intimate affinity to that of lime-stone. A gentle gradation from the one to the other of these substances may be easily traced out; but it will be difficult, I believe, to establish the precise limits of either. Both of them are found in continued *strata;* both of them difsolve in part, with considerable effervescence, in acids; and both of them yield by calcination a quick-lime In the foregoing experiments, however, two very remarkable differences occur: By being exposed to the air, marl falls down into dust; lime-stone retains its original stability. On the contrary, after undergoing the action of fire, lime-stone is reduced to powder by the application of water; marl suffers no such change. This diversity cannot, with justice, be ascribed to the different proportions of calcarious earth in these two bodies. For the marl of Experiment VII. did not contain lefs of this than the lime-stone of Experiment XII. and in the marls of Experiments III. VI. VII. the pro-

* By marls I mean such calcarious substances as are visibly reduced to powder by influence of air and moisture. Such only are real marls. Others, as those of Experiments IX. X. XI. decline towards lime-stone.

portion of this earth was considerably greater than in the marls of Experiments X. XI.; yet, after sufficient burning, the latter relented in water, the former did not. Nay, when a part of a bed of stone, which contained only one-third of calcarious earth, was calcined and put into water, it instantly fell down into powder; whereas marl, containing four-fifths of calcarious earth, underwent no such change from the same treatment.

The cause of the difference then must be sought for in the unsoluble part of these substances. Upon comparing the Experiments related in Sections III. and VI. I observe that all the *residua*, consisting of any considerable proportion of sand, were extracted from substances which, in a natural state, suffered very little change from water; though, after calcination, water immediately reduced them to powder. On the contrary, the *residua* of clay were obtained from bodies poſseſsed of just the opposite properties. That this observation will apply universally, I dare not venture to affirm; but it appears to point out a probable solution of the present difficulty. To explain this in the most intelligible manner, it is neceſsary to observe, 1*mo*, That dry clay suffers a very singular change from immersion in water. For its particles, then gradually receding from mutual contact, come at length entirely to lose their cohesive power; in consequence of which, the whole mafs, after increasing in its volume, crumbles down into powder. *2do*, That clay, by the action of fire, not only acquires a considerable degree of hardnefs, but is at the same time so altered in its nature, that the water can no longer make any imprefsion on it. *3tio*, That sand in its natural state suffers, from the influence of water, no change as to the cohesion of its particles; and that it acquires no considerable hardnefs in the fire. *4to*, That calcarious earth, when uncalcined, suffers as little change from water as sand does; but that, after calcination, it is affected in the same manner by that fluid, as clay is in its natural state. These things being premised, the difficulty is easily surmounted. Upon the exposing of marl to the air, the clay in its composition, moistened from time to time by the rain and dews, gradually moulders away; and, in consequence of this, the cohesion of the whole mafs is at last destroyed. On the other hand, when this marl is calcined, the increased cohesion of its clay locks in the calcarious particles, and, denying admifsion to the water, fupports the maſs against the action of this fluid *. Limestone, on the contrary, and other substances consisting of calcarious earth, or calcarious earth and sand compacted into a solid maſs, undergo no change from being exposed to the air; because none of their constituent parts have their cohesion diminished by the influence of moisture. But, when these substances are calcined and thrown into water, as the calcarious particles then recede from mutual contact with a force which the cohesion of the particles of sand, if there is any, is not sufficient to resist, the whole composition must immediately fall into powder †.

* Stone marls, upon being exposed to the air, divide first into maſses of a considerable bulk. These divisions run for the most part horizontally or perpendicularly, with respect to the natural situation of the marl. Upon examining the divided surfaces, I find them covered with a thin coat of very fine clay, with little or no mixture of calcarious earth. Hence it is evident, why the resolution begins at the parts where this clay lies.

† It would appear that, in clay-marls, the particles of clay are disposed in such a manner as to touch one another, and, at the same time, to prevent the mutual contact of the calcarious particles. According to this disposition, each particle of calcarious earth will be surrounded with a coat of clay. It is difficult to conceive how,

Thus it appears, that marls differ from other calcarious substances, only by containing a certain proportion of clay. On which account, the clafs of calcarious bodies will admit of a division into such substances as in the air fall down into powder, and such as do not.

---

without some such arrangement, the changes mentioned above should be produced. Unlefs the clay cements the calcarious earth, water, which only influences the clay, would scarcely bring about the resolution of marl; nor would the calcination of this substance, which transports the property of relenting in water from the clay to the calcarious earth, produce the effects ascribed to it above. Besides this, water, so far as is yet known, only destroys the attraction of the particles of clay to one another, not the attraction of those particles to any other substance; therefore, unlefs the particles of clay contained in any marl were in mutual contact, the application of water to that marl would produce no effect. On the other hand, when marl of considerable purity is calcined, if the calcarious particles were in contact with one another, not even the increased cohesion of the clay would be able to prevent their separation, considering the quantity of calcarious earth contained in such marls, and the force with which that earth, after calcination, explodes in water. But if you conceive the calcarious particles as separately involved in clay, which in its natural state readily falls down in water, and, after burning, denies admittance to that fluid, all the phænomena are easily accounted for. Besides all this, facts are not wanting to justify the supposition of this arrangement. Acids,

SECTION VII.

The two following experiments were made with a view to discover what change the action of fire produced upon the calcarious earth of marl with regard to its solubility in acids.

---

however strong, cannot extract any calcarious earth from calcined marl, except such particles as lie upon the broken surface; and when these particles are thus carried away, the surrounding particles of clay, though more easily separated, still retain their former situation and attachments; which shows that such particles are fixed to one another, and can support themselves in their place without any afsistance from the calcarious earth. But when water is applied to marl in its natural state, it gradually makes its way through the whole mafs which it reduces to powder. This, therefore, is a proof that the calcarious particles of marl have no mutual cohesion, since the whole mafs moulders down as soon as the cohesion of the clay is destroyed. And, as no acid can find admittance deeper than the surface to difsolve the calcarious earth in calcined marl, we may conclude, that taking out one particle of this earth does not open a pafsage to another; and therefore, that these particles lie in separate cells. From what is here said, we may plainly see the necefsity of pulverization in Experiments XVII. and XXII.; and likewise how it happens, that when the clay, mixed with a calcarious earth, is below a certain proportion, the composition, when burnt, cannot resist the influence of water. It may be here asked, how it happens that acids can find admittance to the calcarious earth of marls, even in their

Experiment XXII.

Thirty grains of the marl of Experiment III. were, by burning, reduced to twenty. These just taken from the fire, and powdered, were mixed with a quantity of diluted acid of sea-

---

natural state, as each particle is supposed to be surrounded by a coat of clay? As to this particular, it must be considered, that acids contain a considerable quantity of water, which acts upon the clay, at the same time that the acid is acting upon the calcarious earth. Hence it is that the addition of water to the purer acids, facilitates the resolution of the marls to which they are applied. Besides this, in all pieces of marl, some particles of calcarious earth must be exposed. The acid, in difsolving these, sets at liberty their entangled air. This now restored to an elastic state, pushes every way with great force, breaks the shells of clay contiguous to it, and, by that means, exposes more of the calcarious particles to the contact of the acid. Thus the solution is carried on.

Some of the foregoing reasoning may be applied in favour of the following supposition. It is probable, that in a compound consisting of calcarious earth and sand, the particles of the former surround and cement those of the latter. From this arrangement it is, that when such a composition is calcined and put into water, the whole relents into powder, though only the calcarious earth is affected. In the same manner, when acids are applied to this calcined substance, they find no difficulty, even without a previous pulverization, and without the afsistance of effervescence, to reduce the whole to powder; because they difsolve the cement.

salt *. No visible effervescence ensued upon the mixture; but a remarkable degree of heat was generated. When as much of the acid was added, as I judged necefsary to difsolve all the calcarious earth contained in the marl, I filtered the mixture in the usual way. The residue weighed four grains, did not concrete by drying, and was considerably whiter than the residue of the marl in its natural state. The filtered liquor was of a yellowish hue, and, upon the addition of an alkaline solution, precipitated twenty-eight grains of a reddish powder.

XXIII.

Twenty grains of shell marl, calcined in Experiment XXI. generated, with the acid of sea-salt, a considerable degree of heat, but without any effervescence. The unsoluble residue weighed thirteen grains, and the powder precipitated from the filtered liquor, eighteen.

* The caution formerly given with regard to procuring lime-water from calcined marl, must also be observed in the application of acids to this body; for, without a previous pulverization, the experiment is generally unsuccefsful.

Two circumstances, worthy of attention, occur in these Experiments. The one is, the absence of effervescence during the solution of the calcarious earth; the other is, the remarkable difference betwixt the weight of substance carried off from the marls by the acid of sea salt, and the weight of the powders afterwards precipitated from that acid.

Both these unusual appearances may be easily accounted for from Dr. Black's ingenious experiments *. As to the first, the effervescence which ensues upon the application of acids to any calcarious substance in its natural state, proceeds solely from the expulsion of air contained in that substance. Calcarious earths are, by calcination, totally deprived of their air; therefore those earths, in this state, never can excite any effervescence with acids. Hence the absence of any such commotion in the two foregoing experiments is easily explained.

As to the other circumstances, calcarious earths by calcination lose about a third of their weight. This lofs is found to proceed from the expulsion of air and moisture naturally

* Edinb. Phys. Efs. vol. II. Art. 8.

contained in such earths. Both this air and moisture, and consequently the original weight, are, according to Dr. Black's observations *, restored to such calcined substances by dissolving them in acids, and then precipitating them by an alkaline salt. As the marls employed in the foregoing experiments had undergone the action of fire, their calcarious earth would necessarily be deprived of its natural proportion of air and moisture; on which account, the solution of this earth in the muriatic acid, and its subsequent precipitation, by restoring what was lost in the fire, could not fail considerably to increase its weight. And from thence it happens, that the weight of the precipitated powders, added to that of their respective residues, equalled pretty exactly the weight of the marls before calcination.

It may be also remarked, that the burnt marl of Experiment XXII. yielded a smaller proportion of residue than the same marl in its natural state did. For when this marl was examined as taken from the pit, its unsoluble parts were nearly a third of the whole; after undergoing the action of fire, they did not

* Treatise formerly cited.

exceed a fifth *. This difference, I imagine, is the effect of iron contained in the present marl. Iron in ore, discovers none of its metallic properties, and consequently is not then soluble in any of the acids †. But when a body containing iron is calcined in contact with an inflammable substance, that metal immediately afsumes its distinguishing qualities, and of consequence becomes obedient to the magnet, and soluble in acids. Therefore when our marl, in its natural state, was examined

* They did not amount to a seventh part of the weight which the marl had before it was put into the fire. For the weight of the marl then was thirty grains, the weight of the residue extracted after calcination was only four.

† From a late observation, I have some reason to doubt the truth of this afsertion. Whilst I was examining some shell marl, the following unusual appearances occurred to me during its effervescence with the muriatic acid: A pungent sulphureous vapour struck the nose; when the effervescence was at an end, the acid had acquired a peculiar disagreeable styptic taste, resembling the taste of the *tinctura martis*. Upon the addition of an alkaline salt to this liquor, when filtered, an ochrey film rose to the surface; and a brown-coloured powder fell to the bottom. Having re-difsolved part of this precipitated powder in the acid of sea-salt, I added to the solution some drops of the tincture of galls. Instantly a deep black colour was produced by the mixture. The ex-

by the acid of sea-salt, the iron contained in it suffered no change, but remained in the filter as part of the residue. On the other hand, when this marl, surrounded on all sides by burning pit-coal, was properly calcined, its iron became soluble in acids, and consequently fit to paſs through the filter, with the calcarious earth invisibly suspended in the acid of sea salt. Thus it is evident that, in all marls containing iron, the proportion of unsoluble parts must be diminished by calcination. A

---

istence of iron in the marl under examination being thus demonstrated, I wanted to know what proportion of that metal was contained in this substance. For this purpose, having mixed fifty drops of the acid of sea-salt with one hundred and twenty drops of pure water, I diſsolved in this mixture ten grains of the precipitated powder above-mentioned; consequently seventeen drops of this solution contained a grain of the powder. Into twelve ounces of water were put seven drops of this solution. In an equal quantity of the same water was diſsolved half a grain of pure salt of steel. To each of these were added forty drops of a tincture of galls. The water which contained our solution became thereby considerably darker in its colour than the other. Therefore ten grains of the precipitated powder contained more iron than fourteen grains and a half of pure salt of steel. This marl communicated none of its iron to plain water. About a third part of its substance was soluble in the acid of sea-salt.

proof of the existence of iron in the marl under consideration, is its acquiring a reddish cast in the fire, which all clays that contain iron are observed to do. That this iron remains with the residue, when the marl is analysed in its natural state, and pafses off with the calcarious earth, when the analysis is performed after the marl is calcined, is evident from some circumstances in the foregoing experiments. For the calcarious earth, extracted from marl in its natural state, was always white * ; the residue by the the action of fire became red †. On the other hand, the calcarious earth of calcined marl had a reddish appearance, and the residue was white ‡.

SECTION VIII.

All the foregoing experiments were directed towards the resolution of marl. I next attempted an artificial composition of this substance.

Experiment XXIV.

Seven parts of pure chalk were mixed, and,

* Experiment XV. † Experiment IV. ‡ Experiment XXII.

by the afsistance of water, well kneaded with one part of tough clay. This paste, when dry, relented suddenly upon the application of water. Water also readily reduced it to powder, after a sufficient calcination. From this, and the Experiments IX. and XX. it appears, that all proportions of clay and calcarious earth compounded together, will not resist the influence of water applied to them after calcination.

XXV.

Four parts of chalk were properly kneaded with one part of clay, and dried. This mixture, when calcined and put into water, suffered no perceptible change. The event was the same, whatever proportion of clay was used; provided this was not lefs than the proportion employed in the last composition.

XXVI.

Four parts of chalk, one part of sand, and one of clay, were well kneaded together, and dried. When this mixture was put into water after calcination, it cracked in several places, but did not fall down into powder. From this we see, that the addition of a little sand to the proportions used in the last experiment, makes a composition unable, when sufficiently burned, to resist the influence of water. And this happens, because such an addition augments the surfaces to be connected farther than the clay can be properly extended. For this reason it is, that a greater proportion of sand than what is employed in this experiment, gives a composition which the action of fire renders unable to resist water in the smallest degree. Compare Experiments VII. and VIII. with Experiments XVIII. and XIX.

XXVII.

Six parts of chalk, two parts of sand, and one part of clay, gave a composition, which, when calcined and put into water, immediately fell down into powder. I have seen a lime-stone consisting of the same proportion of earths.

It may be remarked, that though the last composition, and that of Experiment XXIV. quickly relented in water after calcination, yet many little mafses in both suffered no change. This was probably owing to some inequalities in the mixture, by which the particles of clay were in some places allowed to remain in contact with one another.

XXVIII.

Equal parts of quick-lime * and sand were kneaded together and dried. In this state the mafs suffered no change from water; but when properly burnt, it exploded in water with considerable violence.

XXIX.

A piece of old mortar, after calcination, fell down immediately in water. This mortar, examined by the acid of sea-salt, appeared to consist of calcarious earth and sand, in equal proportions †.

Thus it is manifest, that calcarious earth and clay constitute a substance pofsefsed of the properties of marl; and that a mixture of the same earth and sand, even in equal proportions,

* I could by no means make crude calcarious earth cohere with sand in such a manner as to resist either the slightest touch, or the influence of water.

† In the same manner, the proportion of sand in any mortar may be easily examined; and, consequently, the composition of such mortars as have, for many ages, withstood the effects of time, may be thus discovered.

is not destitute of the most distinguishing characters of lime-stone. These circumstances serve to support the account formerly given of the natural composition of marl and lime-stone, whilst at the same time they show that marls, considered as calcarious bodies, may surpafs many lime-stones in purity. Marls, however, are limited in the proportion of their calcarious earth. They cannot, according to my observations, contain much above four-fifths of it. Lime-stone may consist entirely of this earth.

From the affinity betwixt marls and lime-stone, we may see whence it happens, that a bed of the latter is often found interposed betwixt two beds of the former. The calcarious earth in both is the same. The subsidence of clay in the one case, and sand or nothing in the other, along with that earth, makes all the difference. Among beds of marl, a bed of coarse stone sometimes occurs. This stone, however, I have generally found to contain a considerable proportion of calcarious earth; but the quantity of this earth was too small to procure the stone the denomination of lime-stone; and the quantity of clay in it was not sufficient to intitle it to a place among marls.

SECTION IX.

Having in this manner analysed marl as newly dug from the ground, I next proceed to examine this substance after its exposition to the air. The Experiments III. IV. XV. XVI. XVII. were repeated upon marls that had been exposed for many months. The events were the same, as when the experiments were made upon newly-dug marl; nay, part of a *stratum* of stone-marl, after it had been exposed for three years to the open air, and had undergone all the visible changes that usually proceed from such an exposition, discovered the same proportions of calcarious earth and clay, as when it was taken from the pit.

Marl, when used as a manure, is generally supposed to attract from the air a certain acid spirit, with which it combines into a neutral salt, the powerful promoter of vegetation. I shall here add an account of two experiments, made with a view to ascertain the existence of that salt.

Experiment XXX.

Two drachms of clay-marl, which had been exposed to the air for six months, were digested, with a considerable heat, in ten ounces of water. This water, after twenty-four hours, was filtered off, and the same quantity again added. After the same space of time, this second water was also filtered off. The marl being then dried, wanted a grain of its original weight. None of the filtered waters suffered any change from the addition of an alkaline salt. Both of them were, by a gradual evaporation, reduced to the quantity of an ounce. This differed in no visible manner from the waters before evaporation, except that, after standing a little time, it deposited a small quantity of a grayish insipid earth, which, after a very brisk effervescence, difsolved entirely in the acid of nitre. Nothing but such an earth remained, when the evaporation was pushed to drynefs.

XXXI.

Two drachms of shell-marl, which for three years had been exposed to the open air, were treated precisely in the manner described in the foregoing experiment, and in every respect with the same appearances. The marl, after digeftion, wanted half a grain of its original weight. The filtered waters suffered no change from the alkaline solution, and left, upon evaporation, a small quantity of calcarious earth.

These two experiments seem to contradict the common opinion with regard to the operation of marl in agriculture; for the marls here employed had certainly been exposed as long as might have been sufficient for the attraction of a considerable portion of the aërial acid, and the consequent formation of a sensible quantity of a neutral salt. But these marls evidently contained nothing of a saline nature. For, by digestion in water, the proper *menstruum* of every salt, they suffered in weight no diminution of any consequence. The grain wanting in Experiment XXX. and the half grain in Experiment XXXI. may be safely allowed as the consequence of loſs of substance, which no attention can prevent in the proceſs of such experiments. But supposing this diminution of weight really to proceed from the solution of some saline substance, such an inconsiderable quantity of salt will by no means account for the effects produced by marl; therefore these effects must proceed from some other cause.

The filtered waters left, upon their evaporation, a substance which did not in the smallest degree partake of the nature of salt. Besides this, an alkaline solution added to these waters produced upon them no visible alteration; which would not have been the case, if they had extracted any thing of a saline nature from the marls. For, as marl contains no alkaline salt *, the calcarious earth alone of this substance could serve as a basis for the formation of a neutral salt; and it is well known, that all such neutral salts are, after solution in water, immediately decompounded by the addition of an alkaline salt, which never fails to throw the earth to the bottom in form of a white powder. Therefore, if our waters had extracted any salt from the marls with which they were digested, the alkaline solution would infallibly have discovered it †.

It may be objected, that the heat employed in the foregoing experiments was too incon-

* Experiments I. II.

† Having dissolved twenty-seven grains of pure chalk in a drachm of the nitrous acid, and mixed the solution with five drachms of water, I found that one drop of this mixture could, by the alkaline solution, be discovered in two ounces of soft water. But no more than a sixth part of that drop, at the utmost, can be considered as salt; therefore one drop, equal in weight to a grain of pure salt, will be discoverable in twelve ounces of water.

siderable to promote the solution of the salt contained in the marls under examination. But, to obviate this objection, it must be considered, that the heat, in which these experiments were made, greatly exceeded any heat to which the soil in our climate is ever exposed. From whence it is evident, that whatever proportion of salt our marls may acquire from the air, this salt never can contribute by its solubility to vegetation; and consequently marls cannot act in the manner that is generally supposed. Besides, to remove all doubt with regard to this point, I boiled in water, during an hour, two drachms of the marl of Experiment XXX. This marl, when afterwards settled by filtration and dried, weighed two drachms and a grain.—The filtered water suffered no change from the alkaline solution. This experiment was repeated with the same appearances upon the shell-marl of Experiment XXXII.—Hence it is manifest, that our marls, by exposition to the air, had acquired nothing of a saline nature.

In Experiments XXX. XXXI. it is mentioned, that the digested waters left, upon their evaporation, a small quantity of real calcarious earth. Lest this earth should be suspected to proceed from some marly salt decompounded in the progrefs of the evaporation, it must be observed, that the pure fountain water employed in these experiments, deposited, by the same treatment, a quantity of calcarious earth equal to what was afforded by the digested waters; and, from this circumstance, we may perceive whence proceeded the increase in the weight of the marl which had been subjected to so long boiling.

Upon the surface of some marly rocks which looked towards the north, and had been exposed time immemorial to the open air, I found a thin white efflorescence. In many places, where water trickled down from the rocks above, mofs, to the thicknefs of some inches, had been in time accumulated, and was now crusted over with a hard white substance. Below this crust, the different plants of mofs were found disposed in a very regular manner, and soldered together by a substance similar to the crust. Here I expected to have found the salt of marl, but could not, by any treatment, discover the smallest indication of it. The mineral acids, after a very brisk effervescence, difsolved entirely both the efflorescence from the surface of the rock, and the matter which adhered to the mafs. From this circumstance it appears, that these substances consisted solely of the calcarious earth of the marl, freed from the other earths, by the moisture, &c. whose action it had for many years undergone.

These marls were exposed alone to the air. Whether, when incorporated with the soil, such substances may be more readily converted, in their calcarious part, into salt proper for the nutrition of vegetables, experiment alone can determine. Some circumstances in the manufacture of nitre seem to persuade us that they may. On the contrary, observations are not wanting which appear to take greatly from the probability of such an opinion; for marls are found to produce the most remarkable effects on light exhausted soils, where they can find little or nothing proper for furthering the nitrous procefs, or the production of any salt we are yet acquainted with. However that may be, I think we are authorised by the foregoing experiments to afsert, that marl acquires nothing of a saline nature by being exposed alone to the open air*.

If no salt is formed upon marl from its exposition to the air, how does marl operate? An answer to this questiod would necefsarily lead us to consider the operation of manures in general; a subject too extensive and intricate to be discufsed within the narrow limits of this efsay.

---

* The following observation, however, must not be concealed. Upon a *stratum* of marl, which, with others, had been exposed for ages to the open air, I found a whitish saline efflorescence in considerable quantity.— This efflorescence was moist, and difsolved readily in water. An alkaline salt added to a solution of it immediately precipitated a calcarious earth. After separating this earth by filtration, the remaining liquor afforded, by a proper evaporation, many distinct crystals of a cubical figure. They tasted like sea-salt, crackled in the fire, and, by the addition of the vitriolic acid, emitted copious suffocating fumes. Hence it appears, that the salt found upon this marl consisted of the muriatic acid, united to calcarious earth. It is singular that no vestige of this salt appeared upon any of the beds of marl but one, and this one had nothing peculiar either in its composition or situation. It differed from the rest in this only, it was pofsefsed of a greater degree of moisture.

ESSAY XVIII.

On Agriculture and Manufactures.

THE improvement of agriculture is an object of more real importance to Great Britain, than any that we can ever have in view. Our commerce and manufactures are very productive; but, if in search of this kind of wealth, we neglect the necefsaries and comforts of life, we shall retain the shadow, and lose the substance; while in the act of doing so we incur the risk of losing both our spirit and independence, together with that importance among nations which we have gained; the necefsary effect of our becoming dependent on others for our subsistence.

Agriculture, as the first and most important object with all nations of territory, should be carried to the greatest pofsible perfection, before any considerable encouragement is given to manufactures. It ought, indeed, to be considered as the life and soul of all manufactures, which will every where prosper and flourish nearly in proportion as the agriculture of the country is more or lefs in a state of perfection.

Some, indeed, who are accustomed to believe that every thing may be accomplished with money, are induced to suppose, that by giving full encouragement to manufactures; bringing them to a state of prosperity, and thereby attracting wealth from abroad, that we must necefsarily encourage our national agriculture at the same time. But, in reality, this is seldom found to happen; perhaps in no instance whatever with countries that pofsefs any considerable extent of territory. Nations abounding in population, as well as in the necefsaries of life, will always derive advantage from a flourishing state of their manufactures; and the wealth which these produce will give farther encouragement to the improvement of their soil. But where money is already abundant, and the population not great, as is precisely the case with this country at present, manufactures, if carried beyond a certain extent, will be productive of the very contrary effect; and may even be carried so far as completely to check the improvement of land. In this state of a country, a few opulent merchants and manufacturers, may improve the small landed properties which they poſseſs, in the highest poſsible manner; while a great proportion of the contiguous districts, and even of the whole lands in the nation, equally fit for cultivation, may remain for ages in a state of slow improvement.

If much larger profits are to be obtained by manufactures than can poſsibly be got in agriculture, and if higher wages are given to workmen in the one line than the other can afford, as now is undoubtedly the case in this country, the money-capital of the kingdom will be withdrawn from every scheme connected with agriculture, and placed in manufactures; at the same time that labourers will daily become more difficult to procure, and at last too expensive to admit of being employed. Even at present, this is so far the case with us, that in many districts agriculture is not advancing, and evidently from this cause. For, over the whole nation, it will be found, that while improvements in tillage are still carried on with spirit in counties not poſseſsed of large manufactures, they are very commonly in a state of languor, and even falling behind, where these have prevailed in any considerable degree; which not only attract almost the whole labourers of their several districts towards them, but even the monied properties of the landholders, as well as of the farmers, who from the temptation which the profits of these extensive works hold forth to them, are often induced either to become partners in them immediately themselves, or to fix their sons in them as partners: by which their farming capitals being diminished, all farther improvements of their farms are either put entirely out of their power, or they proceed with much leſs energy and effect. So far, indeed, has the influence of this in many districts gone, that if it be not quickly counteracted, more national harm is likely to ensue from it than all the wealth which the most flourishing state of our manufactures can produce, will ever be able to compensate.

Nor is our situation, in this important point, in any degree singular: similar causes will every where be productive of similar effects. And, accordingly, in every kingdom of Europe, (I am still alluding to nations poſseſsed of considerable territorial property) such as France, Germany, and Italy, it is well known that, with scarcely any exception, agriculture has been most perfectly carried on in those places where extensive manufactures have never existed.

I do not from this mean to conclude, that manufactures in this country ought not to be encouraged; but I consider it as a fair argument in support of an opinion which I wish to establish, that while any considerable part of our improveable territory is left neglected and unproductive, particularly while we are obliged to apply yearly to other nations for a large supply of corn, which an improved cultivation of our own fields would render unnecefsary, it is for the general interest and security of every part of the realm, that the most decisive encouragement should be given to agriculture: by which abundance being secured of all the necefsaries of life, with their constant concomitant, an extensive population, every manufacture in the kingdom might then with more propriety be encouraged, than can with safety be done at present.

Some have been induced to suppose, and even boldly to afsert, that the agriculture of Great Britain cannot be brought to a higher state of perfection than that to which it has already attained: but this is so entirely contrary to fact, that all who are versed in rural affairs will admit, that, with due encouragement, our agriculture might with ease be improved so as to yield considerably more than double; probably, three times the present amount of it. For it is not merely the commons and those grounds usually termed wastes, and of which the quantity over the nation is very great, which require improvement: on almost every farm, except perhaps in a few districts of naturally rich soil, and which have long been in a state of high cultivation, every farmer will allow, that with more ample funds, the produce might be greatly increased; by which we might not only be rendered at all times, and in all circumstances, completely independent of other nations for our supplies of corn, but enabled to support a much more extensive population! Objects of such magnitude and importance, that, in the view of national strength, security, and comfort, scarcely any other can be compared to.

Nor would it be either difficult or expensive to give such encouragement to this source of wealth and prosperity, as, in no great length of time, would carry it to a degree of perfection which it may otherwise never be able to attain. All that a scheme for this purpose appears to require, is an annual and generous allowance in money, which the nation, even in the expensive war in which it is engaged, appears to be sufficiently able to afford; this money to be placed under the direction of the Board of Agriculture, to be employed in giving animation to the husbandry of the united kingdoms. The immediate advantages would be, that it would quickly produce a more ample supply of all the necefsaries of life, than hitherto we have ever pofsefsed, together with all the beneficial effects which never fail to result from their being abundant. And here I beg leave to observe, that, among other improvements, a particular encouragement should be given to the cultivation of potatoes, which, being a nutritious and perishable root, will at all times operate against the combination of monied men; who having it in their power to hoard up all kinds of grain, can, by that act, make a plentiful harvest have the same operation upon the public as a bad one. Agriculture, under due encouragement, will necessarily tend to a rapid increase of population; and by exciting in our youth a greater bias for the improvement of land than for manufactures, it would render them more healthy, more attached to their country, and therefore more to be depended on for its protection, than men can in general be whose lives are usually spent in difsipation, as too frequently happens with the lower clafs of manufacturers, when collected, as they now commonly are, in large numbers together; and who seldom place any value upon a country; but in proportion to the money that they receive in it for their workmanship. Exceptions to this are, no doubt, to be met with; but it must be admitted, that a nation, whose youth consists mostly of manufacturers, will never be so secure or independent, as it would be with the same population employed in the cultivation of land. We have now the satisfaction of knowing that the population of England is not lefs than ten millions; and as it is incumbent upon Government to provide for the support of so many persons, without having recourse to foreign nations for every kind of grain, I flatter myself that the adoption of the annexed plan will be attended with the material advantage of letting us know the quan-

INSERT FOLDOUT HERE

tity of land that ought to be in constant cultivation for the maintenance of a given number of people. Upon the supposition that seven millions of persons eat wheaten bread, about six millions of acres should be annually employed in raising wheat sufficient for eighteen months consumption. This, in a few years, would place us in the amiable situation of being exporters of grain to a considerable amount: a thing devoutly to be wished for. Notwithstanding there can be neither difficulty nor danger in the execution of this plan, I am convinced that Parliamentary authority will be required towards attaining regular and correct Returns from the respective parishes.

The mildneſs of this mode is a great recommendation to it. Measures of a more rigorous nature would not be well received.

ESSAY XIX.

On Goose Dung.

————————nihil improbus anser,
Strymoniæque grues, et amaris intuba fibris,
Officiunt, aut umbra nocet————

VIRG. GEORG. Book I. v. 119.

MR. HOLDSWORTH, in his very judicious remarks upon Virgil, makes the following observation upon the above pafsage.

"Virgil speaks of geese, as a very troublesome bird, and very pernicious to corn.— They are still so, in flocks, in the Campania-Felice, the country which Virgil had chiefly in his eye when he wrote the Georgics."

In that remarkable long and severe frost, which happened in the year 1739-40, vast flocks of wild geese came and settled upon the green corn in many parts of Cambridgeshire and Huntingdonshire, which were nearest to the Great Bedford-Level. The farmers, it being quite a new visitation, were very greatly alarmed, thinking their crops would be entirely ruined by the depredations of those voracious birds; but very soon after their departure, all those fears subsided, and they were agreeably surprised in finding, that those corn lands which had been most preyed upon by such new visitants, gave as pleasing a prospect for a plentiful crop, as those that had not been touched at all by them. The very uncommon severity of that remarkable winter, locking up all those watery resources for food, within the lower and interior parts of that great level, obliged the birds to migrate in search of it elsewhere; and having found a new and palatable supply from the green corn, they have ever since come up in vast flocks upon the setting in of severe frosts, and feed upon it, undisturbed by the farmers, as long as the cold weather lasts; their dung and their trampling, being found, from experience, serviceable, and not in any respect prejudicial. It must be observed, that they chiefly rest upon the outlaying lands, or those at a good distance from the towns or villages; and that those lands are generally of a lighter nature of soil, and also poorer, than those in the lower parts of the common fields, which come in for more than a proportionate share of the yard dung. The green corn, especially the rye, being also commonly depastured, in those lower parts of the field, with ewes and lambs; a most noble advantage to the farmers, where the land is in sufficient heart and strength to allow it. What I would wish to infer from the above observations, is, that general rules, in regard to practices in husbandry, will seldom hold just and true; I do not doubt, but the wild geese coming in such vast flocks upon the green corn in the Campania-Felice, might, in the time of that very accurate and judicious writer, be found to do injury to the crops; and, pofsibly, the same observation may still hold true—*much* depends upon the nature of the soil, *much* upon the climate, and, probably, *still much more* upon the *stage* of growth the corn is in when it is preyed upon by those devouring birds. Doctor Martyn is pleased to observe upon this pafsage, "That the goose is injurious wherever it comes, by plucking up every thing by the roots." Columella quotes Celsus much to the same purpose, "Quicquid tenerum contingere potest, carpit." Palladius says, "Locis consitis, inimicus est, quia sata, et morfu lædit et stercore." This notion of the dung of geese injuring the grounds where they feed, still prevails amongst some few country people; but experience will convince us, that grafs grows as well under the dung of those animals as most others. As to those bare places which are observable where geese very much frequent, they are occasioned by their drawing up some of the grafs by the roots, and not from any noxious quality in their dung; as there is great reason to believe it to be of a very fertilizing nature, though not so much so as that of sea-birds, they feeding much upon animal food.

There is a small island at the entrance of the Lancaster channel, called Fowlly Island; a name supposed to be given it from the immense quantities of sea-fowls or birds, that constantly frequent it; the grafs upon it is uncommonly sweet and nourishing; the beef and mutton fed there being remarkably fine flavoured as well as fat. This island maintains an unusual quantity of stock, for the size of it, both summer and winter; and its fertility, as well as the excellent quality of the grafs, are seemingly owing to the vast quantities of dung deposited there by those marine birds. The farmers are so much convinced of it, that they will not suffer those birds to be disturbed, if they can prevent it, at any time; but especially at the breeding season, when the whole island is covered with nests of various kinds.

I am certain that considerable quantities of most valuable manure might be raised by farmers who live near large commons, and keep great flocks of geese, if they would use the best methods of obtaining it. It is observable, that the goose being a domestic bird, generally makes towards its own homestal, or place of breeding, about the close of day, and remains there till about sun-rising. If they were to be regularly housed at night, in some empty out-buildings, and the place, every four or days, littered with straw, or weeds cut down before they perfect their seeds, much valuable manure might be obtained from that neglected source. The same advantage might be reaped by littering the places where other kinds of poultry regularly go to roost, or strewing the places frequently with saw-dust, or coal-ashes finely sifted.—Every three or four weeks the places should be cleaned out, and the dung laid up in heaps to ferment, either by itself, or mixed with soil, or scourings of ponds or ditches, which would considerably increase the quantity, and, for some uses, improve the quality too. By such attentive managements, farmers would probably obtain seven or eight additional loads of excellent manure annually, an object that will not be contemned or neglected by any farmer that understands his businefs well: for the great difference that is found or observed between the management of different persons in that useful businefs, arises more from the very different attention paid to the minutiæ of it, than to the great outlines or general practices; for, he that does not pay daily and hourly attention to the latter, does not deserve the name of a farmer, nor will he continue one long, at least to any beneficial purpose; but he that pays strict attention to the former, will soon experience the manifest advantages resulting from it; his fields, his crops, will evidently show it. Any one versed in the valuable writings of the ancients upon subjects of husbandry, will soon perceive the very great strefs that is laid by them upon an unremitting attention to every pofsible method of procuring manures. The great advantage of folding sheep upon ploughing grounds, is too well known to require noticing; yet there are many sensible writers and farmers too, that think it more eligible to house the sheep every night in proper buildings for the purpose, which are littered with straw, or covered frequently with layers of fresh dry mould, and that the advantage procured by such practice, in the quantity of rich manure obtained by it, will far more than compensate for the additional trouble and expense. There are many good farmers also, in the grazing way, who constantly keep collecting the dung or droppings of their cattle; laying them up in heaps, mixed with straw or other vegetable substances, or with soil. And when the heaps have lain for some time to meliorate, turn them over, mixing with them lime, or sifted dry coal-ashes, or both. This excellent compost is afterwards regularly spread over such parts of their grafs-grounds as stand most in need of such afsistance. Such a practice contributes much to the neatnefs, as well as improvement of such grounds, by preventing partial ranknefs, as well as poverty; a defect that is visible in most lands, where such necefsary attention has not been paid to them.

ESSAY XX.

On the Advantages of raising Potatoes on Fallows.

IN the parish where I reside, the whole of which, except five acres, is my property, there are thirty cottages, containing 131 poor people. I have, for five or six years past, allotted, free from rent, four acres of land, intended to be sown with wheat the following autumn, for the cottagers to plant with potatoes; by which means, each raises from ten to fifteen sacks, equal to 240 pounds per sack, yearly, in proportion to the number of their children: each has not only sufficient for his family, but he is enabled also to fat a pig. They declare, was I to give among them a hundred pounds, it would not be of so much benefit to them; and it is not one shilling out of my pocket, for I have as good, if not a better, crop of wheat from this land, as I have from the other part of the field.

The method I take is this: the latter end of November I plough the land; the frost, during the winter, mellows it: the beginning of March following, I plough it again, and harrow it; at both which times I have little to do with my horses: I then divide it into lots; a man with a large family has a larger lot than a single person, or one who has only two or three children, allowing about five perches (of 16½ feet square) to each in a family: they then plant it, and put over their potatoes what manure they have collected the year preceding (for every cottager has more manure than necefsary for this, from their fires and a variety of other things); and during the summer, after their day's labour is done, they and their wives hoe them; and as every man works more cheerfully for himself than for another, they do not suffer a weed to grow. In October they dig them up; and it is the most pleasant thing imaginable, to see the men, their wives and children, gathering the produce of their little farms, which is to serve them the ensuing winter. Was this plan generally adopted, the labourers would consume but little corn; which would supply the manufacturing towns, and we should have no occasion to import. As four acres are sufficient for thirty families, it would take but a small quantity of land from every farm in the kingdom. The way practised here, is to plant the potatoes in furrows, eighteen inches apart, and a foot apart in the rows. The land about me is of different qualities; on the hills, rather light; in the vale, near the parish, inclining to clay; but all fit for turnips: the potatoes are planted in the low land, being nearer home. The poor, at present, will not live entirely without bread, as many do in Ireland, though potatoes daily get into use more and more; and I am persuaded, was my plan generally adopted, in two or three years the labourers in the country would consume but little or no corn. Thirty years ago, the poor in this part of the country would not eat potatoes, if they could get other roots or vegetables.

ESSAY XXI.

On Drill-Sowing.

THE anatomical investigation of the roots of wheat and other grain, has convinced me of the necefsity of placing all kinds of seeds at a certain depth in the earth, in order to their producing vigorous and healthful plants. For this wise purpose a variety of drill-ploughs have been invented and recommended; but from the expense attending the purchase, and the extreme complication of their structure, there is not an instrument of that kind, as yet discovered, that is likely to be brought into general use.

When I speak of the drill-plough, I do not connect the idea of its working with the horse-hoe. I here consider it only as an instrument for sowing land in equi-distant rows, which, by opening a furrow, shedding the seed and covering it, leaves the land stocked with plants in the manner of broad-cast sowing. Grain sown by the hand, and covered by the harrows, is placed at unequal depths; the seeds consequently sprout at different times, and produce an unequal crop. When barley is sown late, and a drought succeeds, the grain that was buried in the moisture of the earth soon appears, while such as was left near the surface lies baking in the heat of the sun, and does not vegetate till plentiful rains have moistened the soil. Hence an unequality of the crop, an accident to which barley is particularly liable. The same observation, but in a more striking manner, may be made upon the sowing of turnips. It frequently happens that the husbandman is obliged to sow his seed in very dry weather, in hopes that rain will soon follow, and either rolls or covers it with a bush-harrow. We will suppose that, contrary to his expectations, the dry weather continues. The seed, being near the surface, cannot sprout without rain. The husbandman is mortified at his disappointment, but is soon satisfied and made easy by a perfect acquiescence in what he thinks is the *will* of Providence. The scourge that he feels must not be placed to the dispensation of Providence, but has its source in the ignorance of the man himself. Had he judiciously buried the seed in the moisture of the soil with the drill-plough, or harrowed it well with the common harrow, his seed would have vegetated in due season, and bountifully repaid him for his toil.

The man that expects the seed to vegetate by heat alone, little knows the immutability of nature's laws. Heat and moisture, when combined, unfold the particles of matter closely connected in the seed, and, by a kind of fermentation, bring the living principle into action.

The husbandman that knows and studies these sublime truths, will often discover his want of succefs in his want of knowledge. Such a man will never repine at Providence; but, amidst the adverse calamities of seasons, will at all times look up to the Deity with comfort and satisfaction.

Reflections upon this sublime subject cannot be brought down to the level of vulgar minds. Modes more familiar will, in general, be better understood, and more agreeably received. All mankind are not philosophers.

In the year 1769, I prepared a fifteen-acre close for turnips. The land was in fine condition as to lightneſs, and had been well manured. On the 24th of June, I sowed fourteen acres of this field, broad-cast, and harrowed in the seed with a bush-harrow. The remaining acre I sowed on the same day with the drill-plough, allowing fourteeen inches between each row, and set the shares near two inches deep. At the time of sowing, the land was extremely dry, which induced me to make the experiment with the drill-plough, knowing that I could place the seed into the moisture of the soil. From the time of sowing to the fifth day of July we had a continual drought, so that the broad-cast seed did not make its appearance till about the 8th of that month, at which time the drill turnips were in rough leaf, having appeared upon the surface on the sixth day after sowing.

In the driest seasons, at the depth of two inches, or leſs, we are sure of finding a sufficiency of moisture to make the seed germinate. When that is once accomplished, a small degree of moisture will carry on the work of vegetation, and bring the tender plant forward to the surface.

When extreme dry weather obliges the

broad-cast farmer to sow late, he has no opportunity of sowing a second time, if the fly should get into the field. The drill secures him, in some degree, against that misfortune, by giving him a full command over the seasons.

I do not confine the excellence of the drill-plough to turnip seed: It is an useful instrument for sowing all kinds of grain. By burying the seed at an equal depth, it secures an equal crop in all circumstances of the weather. But this is not the only consideration to the cultivator. It saves near one half of his seed, which is an object of importance to the tillage-farmer.

In order to be clearly understood upon this subject, I beg leave to observe, that I here recommend the drill-plough as a good instrument for sowing turnip-seed, when the weather is so dry and sultry as to give the farmer reason to apprehend danger from the late sprouting of the seed. But when the weather favours germination, the broad-cast method, by being more expeditious and leſs expensive, will in general be preferred.

When the farmer chooses to introduce the horse-hoe, the drill must then be recommended in all seasons, on account of its distributing the seed in rows. The shares must be placed deeper, or shallower, according to the drynefs or wetnefs of the season.

Was I to give my opinion upon the best method of raising turnips, I should not hesitate one moment to declare in favour of the drill and horse-hoe, with intervals of three feet; but an enlargement of this subject does not come within the idea of the present efsay, which only respects the drill culture, in equi-distant rows, independent of the horse-hoe.

Having sufficiently enlarged upon the necefsity of lodging the turnip seed within the earth during an extreme drought, I shall now proceed to an experiment made upon barley, with a view to recommend the sowing of that grain, as well as all others, by the drill-plough, in preference to the customary method.

In the spring of the year 1769, I sowed an acre of barley, in equi-distant rows, with the drill-plough, in a field which was sown with the same grain, and upon the same day, broad-cast. The broad-cast took three bushels per acre; the drill required only six pecks: This circumstance is worthy of observation. The drills were eight inches asunder, and the seed was lodged about two inches within the soil. The drill acre was finished within the hour, and the most distinguished eye could not discover a single grain upon the surface.

In the course of growing, the drill barley seemed greener, and bore a broader leaf than the broad-cast. When the ears were formed throughout the field, the ear of the drill barley was plainly distinguished to be near half an inch longer than the broad-cast, and the grains seemed fuller and better fed. This appearance occasioned a general surprise, and I confefs I was at first at a lofs how to account for this apparent difference.

Reflecting upon some experiments, that I had made upon the roots of wheat, I was induced to dig up some roots of the drill and broad-cast barley, and was most agreeably surprised to find the cause of the difference to be in the roots. The pipe of communication between the *seminal* and *coronal* roots of the drill-barley, was considerably longer than the broad-cast. And upon that appearance I was convinced that the length of the ear, and the strength of the straw principally depended. I shall not here repeat what I have formerly advanced upon the shape of the roots of wheat. The curious reader will find that subject clearly and satisfactorily explained in the fifth eſsay of this book. Without an attention to this simple mechanism, it is impoſsible for the cultivator to have any adequate idea of the vegetation of corn. It is matter of surprise that such a self-evident truth should have hitherto escaped the observation of naturalists. Upon it the doctrine of top-dreſsings depends. Every person knows their use, but few can explain the manner of their operation. But to return.

The product of two hundred square yards of the broad-cast and drill barley, was carefully housed, and afterwards thrashed out. The drill exceeded the other nearly one-fifth in measure, and being a bolder and better grain, weighed heavier, at the rate of two pounds in the bushel.

From the experience that I have had of the drill-sowing, I can recommend it as a most rational and judicious practice. But as it has many difficulties to overcome, I apprehend it never will be brought into general use. A proper instrument is wanting that would come cheap to the farmer, and have the requisites of strength and simplicity to recommend it. The present instruments cannot, by any means, be put into the hands of common servants. Should we ever be so happy as to see this objection removed, it is probable that all kinds of grain will be cultivated in drills. Corn growing in that manner has a freer enjoyment of air, and the farmer has an opportunity of hand-hoeing and weeding without injury to the growing crop. This is an object of the utmost consequence in the cultivation of beans and winter corn.

Wheat placed into the earth by the drill plough, is not liable to be turned out after frosts: The *seminal* root serves the purposes of an anchor. This is a consideration of great consequence to the farmer.

Much more might be advanced upon this curious and interesting part of agriculture, but I flatter myself that these loose thoughts will be the means of awakening the attention of others, who have more leisure and greater abilities than I have

After what I have advanced it will be needleſs to observe, that in this eſsay I only mean to recommend the drill-plough for sowing the land in equi-distant rows, instead of distributing the seed by the hand in the manner called broad-cast. The drill, when connected with the horse-hoe, constitutes quite a different system, which has great merit when judiciously conducted.

It will not be improper to observe in this place, that most gentlemen who have favoured the public with comparative experiments between the drill, in equi-distant rows, and the broad-cast, or old method, have chosen an improper distance between the rows, and by that means rendered their comparative trials inconclusive. A foot is the distance generally taken, which, beyond doubt, will not only encourage the growth of weeds, but also prove a considerable loſs of land. The distance should never exceed eight or nine inches, and then the comparative trial would be conclusive, as both methods are supposed to be conducted in the most perfect and advantageous manner.

The instrument that I have hitherto used for drilling of grain, is the invention of the ingenious Mr. Craick, and made by Mr. Creighton, coachmaker, in Edinburgh. It works with four coulters, and is the completest instrument of the kind that I know of. The price is twelve pounds. One man, a horse, and a boy can easily sow four acres a day: so that if I was only to estimate the saving in seed, I should readily recommend the drill-sowing in equi-distant rows, as a method worthy of national attention.

Mr. Benson, of Stainly, near Ripon, is the only farmer that I know of, who conducts his whole farm in this œconomical and judicious manner.

ESSAY XXII.

On Manures, and their Operation.

IT is observed, that there are substances, which, when mixed with the earth, greatly promote vegetation. These are called manures. To apply manures in such a manner, as most effectually to promote vegetation, it is of importance to know their natures, and the ways in which they operate. This is the more necefsary, as, without it, we cannot know how to apply them in the most proper manner to the different soils.

To inquire into these things is the design of this efsay.

Manures operate in all the different ways by which vegetation is promoted.

They operate, by communicating to the soil, with which they are mixed, the vegetable food which they contain; by communicating to it a power of attracting this food in greater plenty from the air; by enlarging the vegetable pasture; and by dissolving the vegetable food which it is already possessed of, and fitting it for entering the roots of plants.

Manures are very different in their natures. Some of them operate in all the ways mentioned, and there are none of them that do not operate in more ways than one.

Great mistakes have arisen, from supposing that manures operate only in one way. None have been attended with greater loss, than supposing that they serve only to divide the soil, and that tillage may be substituted in their place. This is Mr. Tull's opinion; and is, indeed, the fundamental principle of his horse-hoeing husbandry.

Before one changes the ordinary practice of agriculture, in so important a point as banishing manures from his fields, the good effects of which are so obvious; he must be certain, that the principle which determines him to so important a change, is itself well founded.

Mr. Tull has endeavoured to prove, that

earth is the food of plants; and hence infers, that to divide the earth into minute particles, by which it is fitted for entering their roots, is all that is necefsary in agriculture: And this, he afserts, may be done by tillage, without manures.

But it is abundantly evident that other principles, besides earth, are in the composition of this food: And, if this is true, the want of manures, which provide these other principles, cannot be supplied by tillage.

Supposing we allow, with Mr. Tull, that earth is the food of plants, yet still it does not follow, that tillage may supply the place of manures. It is certain, that every particle of earth which we observe, is not of the kind that is the food of plants. Every soil is a composition of different earths; several of which, it is obvious, are not of this kind.

The great difference in soils, equally pulverised, is a plain and convincing evidence of this. Now, let it be observed, that the earth contained in dung is of this kind; it has already been food to plants, and therefore though all that is contained in the greatest quantity of dung laid on at one time, is but small in proportion to the quantity of soil employed in vegetation, as Mr. Tull justly observes; yet it may be considerable in proportion to the quantity that is really the food or *pabulum* of plants. If the quantity of earth contained in the quantity of dung commonly laid on at one time, is compared with the quantity of earth contained in the richest crop, it will be found several times larger; and therefore, by the laying on of this dung, food is provided for several good crops.

Besides, let it be observed, that the mechanical action of the plough cannot increase the number of the particles by which plants are nourished; they are so small as not to be observed in water. Mr. Tull supposes, that they are as small as those upon which the colour of bodies depends. Now, though pounding earth in a mortar may perhaps do something to increase them, yet the action of the plough can never be supposed to do it. The plough can do no more than open the soil, or enlarge the pasture of plants, and allow them to extend their roots in search of their food, but does not increase the quantity of it; and therefore tillage cannot supply the place of dung, which not only opens the soil by its fermentation, but also increases the vegetable food by the earth which it contains.

It may be further observed, that the fermentation raised by dung, continues for a considerable time; so that though, by ploughing, the soil may be as completely divided as by the fermentation of dung, yet it will not continue so; for, after seed is sown, the artificial pasture raised by ploughing is continually decreasing while the crop is growing; whereas the artificial pasture, raised by the fermentation of dung, is continued by the continuance of this fermentation; and therefore, though in the horse-hoeing husbandry, the want of dung may be supplied by hoeing, yet, as Mr. Tull indeed observes, dung is still necessary in the old husbandry.

If persons attentively consider the effects of manures, it will appear that they operate in all the ways mentioned.

Manures are found to enrich the best pulverised soil; and to do this again and again, after it is exhausted by crops. It is almost an universal practice to lay dung upon land that is kept constantly in tillage, once in three, four, or five years. It is observed, that after the dung is laid on, the land becomes rich, and that the crops turn gradually worse and worse, till the whole virtues of the dung are exhausted; and it is also observed, that immediately upon the dung being again applied, the land becomes rich as before. It is natural to conclude from this, that dung promotes vegetation by increasing the quantity of the vegetable food.

It is found, that some manures lose part of their virtues by being long exposed to the air. After dung is sufficiently rotten, the longer that it lies it becomes of leſs value, and does not enrich so large a quantity of land as when used in proper time. The dung of cows dried upon their pasture, gathered, and laid upon other land, is scarcely to be discerned in its effects on the crops produced: The same quantity applied, whether carried from the cow-house, or by folding the cattle, enriches the land. From this it is obvious, that this kind of manure contains the vegetable food in itself, and does not receive it from the air.

It is found that some manures operate the sooner, and with the greater violence, the longer they are exposed to the air; before they are used. Lime and marls are of this kind; the longer they lie exposed, they operate the sooner; and it is observed, that they have a strong power of attracting the virtues of the atmosphere. From these things it is reasonable to infer, that these manures operate, by communicating to the soil with which they are mixed, a power of attracting the vegetable food from the air.

It is observed, that some manures exhaust land of its vegetable food, and do not restore it again when immediately applied. This is found to be the case with lime. Land, thoroughly limed, has been found to carry many very good crops; by degrees, however, the virtues of it have been exhausted, and the land reduced to a worse situation than before the lime was laid on. In this situation lime has been applied a second time, but its effects found to be far inferior to what they were when first applied. This is sufficient to convince us, that this manure operates by dissolving the vegetable food which it meets with in the soil, and fitting it for entering the roots of plants.

It is certain, that all kinds of manures open the soil. Any person will be convinced of the truth of this, who will take the trouble to compare a piece of land, on which dung, or any other manure has been laid, with a piece contiguous that has not been manured; he will find the one much softer, much more free and open than the other. It must be allowed, therefore, that all manures operate by enlarging the vegetable pasture.

Manures are commonly divided into clafses. Some divide them into natural and artificial; others divide them into the fofsil, the vegetable, and the animal, and treat of them in order, as belonging to each of these clafses.

The manures belonging to some of these clafses differ, both in their nature and operation, from those in the other clafses. Some of them likewise differ from others in the same clafs. The dividing them into clafses, therefore, serves no purpose. All that is necefsary is, to treat of the different particulars which the farmer can command, without considering to what clafs they belong

Dung is commonly used to signify not only the excrement of animals, but also all rotten vegetables, when used as manures. In treating of it in this eſsay, we understand it in the first sense of the word.

The food of animals, reduced to a corrupted state, constitutes dung. The stomach dissolves that food, and reduces it to a state of putrefaction much sooner than is done by the air. It is by being in this state of putrefaction that the juices, fit for the nourishment of the body, are conveyed by the lacteals into the blood. While bodies are in a sound state, their parts adhere firmly together, and they are incapable of being turned into the parts of other bodies. To render them incapable of this, they must be reduced to their first principles. This is done by corruption. It is observed, that by corruption all the parts of bodies are relaxed, and the salts, oils, and other juices which they contain, from being fixed are made volatile. It is by being reduced to this state in the stomach, that the things which the animal feeds upon become nourishment to it, and are turned into parts of its body.

All the juices contained in the things which animals feed upon, are not exhausted by the guts; many of them, along with the earthy part of the food, are thrown out. There is no doubt that some of the earthy part of the food goes also to the nourishment of the animal; but as the earth is rendered volatile by the salts and oils, there must be but a small quantity of it, in proportion to the quantity of these, exhausted by the animal; and therefore in the dung there must be a great quantity of earth in proportion to the other principles. However, as the dung contains all the principles of the food, we may consider the dung of those animals that feed on vegetables, as vegetables in a putrefied state.

Of the same nature is the dung of animals that feed upon other animals. Vegetables are the original food. All animals either feed on pure vegetables, or on other animals that feed on vegetables. Animals that feed on vegetables are made up of the same things with vegetables, only under a different form; and therefore the dung of animals that feed upon these, is still to be considered as vegetables in a putrefied state.

Chemists inform us, that dung is compounded of the same principles of which vegetables are compounded; of water, air, oils, salts, and earth. The earth which it contains is of the absorbent kind, and attracts the other principles. They also inform us, that dung attracts and ferments with acids, and by this fermentation produces salts.—A quality of salt, as was before observed, is to attract and difsolve oils, and make them capable of being mixed with the water.

If these qualities of dung are considered, it will appear that it promotes vegetation in all the different methods mentioned.

It promotes vegetation by increasing the vegetable food. It is compounded of the same principles of which the vegetable food itself is compounded, as we endeavoured to show when treating of the food of plants. This is also confirmed by the experience of all places and all ages; and it is what no person will doubt of, who considers that it has the same effects upon land of all kinds, and in all situations.

It promotes vegetation by enlarging the pasture of plants; it attracts acids from the air and soil; and, by raising a fermentation with them, thereby separates the particles of the soil with which it is mixed. Every farmer knows the truth of this from experience. The land upon which dung is laid, though naturally stiff, becomes soft and mellow, and is more easily ploughed than before.

Dung, we have said, enlarges the pasture of plants, by attracting acids, and fermenting with them. These acids are in the soil and air. They are in the soil; for the soil produces acid plants. Chemists tell us, that the neutral salt found in soil is compounded of an alkaline salt, such as is found in vegetables, and an acid spirit. All alkalies are strong attractors of acids; so that, in the procefs of an experiment upon soil, perhaps it may be difficult to keep them separate, though they may exist separate in it. The acid plants prevent these from mixing; or, perhaps, have a stronger power in their vefsels to separate them than other plants have.

But though there may be no acids in soil, excepting in the compound of neutral salts, yet there is no doubt but they are in the air.

Chemists find this by innumerable experiments. Ashes, when exposed to the air, produce neutral salts; the application of acids has the same effects. Any person may observe a salt adhering to the lime of old walls; this salt is not in the lime, it is produced by the air. The same salt is produced by acids. Other experiments might be mentioned, but these are sufficient.

Dung promotes vegetation, by communicating to the soil a power of attracting the vegetable food from the air. The earth which it contains is of the absorbent kind, and attracts all the other principles of the vegetable food; and the salts which it contains and produces, attract oils.

It likewise promotes vegetation, by preparing the vegetable food for the nourishment of plants. By the salts which it contains and produces, it not only attracts oils, but also difsolves them, and makes them capable of being mixed with water. It is probable, that oil is a principal part of the food of every plant which we cultivate in our fields, at least is the ingredient of which it is easiest to exhaust the soil, and which it is most difficult to restore to it again. In proportion to the quantity of oil contained in any plant, in proportion it robs the soil, by which it is nourished, of its vegetable food. But the nature of oil must be changed before it can enter the roots of plants. This change is made by salts; they difsolve it, and make it to mix with water.

Though dung promotes vegetation in all these ways mentioned; yet, as there are other bodies that are much stronger attractors of acids, by which many of its effects are produced, it is probable that it principally operates by increasing the food of plants. Its effects in difsolving the vegetable food in the soil must be very trifling. The salts which it contains and produces, having its own oils to work upon, and being along with them conveyed into the roots of plants, cannot operate with any violence upon the oils which the soil contains. This is confirmed by experience. When the virtues of dung are exhausted, the soil is no poorer than before it was laid on.

Some new improvers are pleased to ridicule the old farmers, because they are so fond of dung; but none will do this who attentively consider the virtues of it. Such manures as can be obtained, are to be used; and tillage is carefully to be attended to: but this must not supersede the use of dung, which can be employed to so great advantage.

The Author of the New System of Agriculture takes upon him to afsert, that dung destroys some land; and that it is as great folly to apply dung to land that requires cooling, as to administer brandy to a man in a fever. He tells the farmers that they mifs a crop by dunging an improper soil, and lay on more dung to remedy the misfortune.—These afsertions may impose upon a man that is fond of novelty and paradox; but, with men of sense and experience, they must bring into discredit every thing that such an author afserts.

Though dung in general has all the qualities mentioned, yet there are some kinds of it pofsefsed of some of these qualities in a higher degree than others. There are as many kinds of dung as there are of animals; and in some respects they all differ one from another.

The difference betwixt one kind of dung and another, is commonly supposed to arise from the different food of the animals. Green herbage, straw, or hay, do not contain so much vegetable food in the same quantity as grain does. Hence it is supposed, that the dung of cows is not so rich as that of horses, nor the dung of horses so rich as that of fowls.

But this difference must partly arise likewise from the nature of the animals, if it be true, that the dung of horses, cows, sheep, hogs, and geese, all differ one from another, though fed upon the same pasture. Some animals digest their food more quickly than others. This makes a difference in the dung produced by the same food. Some things are digested and turned into a state of corruption by some animals, that paſs through others sound and undiſsolved. The matter then in the stomach that digests the food, must be different in the different animals. The dung must partake something of the nature of this, which makes another difference in the dung produced by the same food.

Some writers on agriculture treat of the dung of the different animals separately. But it is needlefs to do this; for it requires more pains and expense to keep them separate, and use each of them by itself, than all the advantages arising from this way, above the ordinary way, can pofsibly amount to.

The dung of fowls, particularly of pigeons, is an exception to this. It is commonly used without any mixture, and it can be kept separate from other dung without any trouble or expense. It is observed, with respect to it, that the effects of it are more violent, and sooner over than the effects of common dung. The effects of some other kinds of dung would perhaps be the same, if they were used without any mixture. The dung of pigeons, being thoroughly corrupted, soon difsolves, and becomes vegetable food. But the straw, with which the other kinds of dung are commonly mixed, not being so thoroughly corrupted, prevents the effects of them from being so violent, and so soon over.

The way in which pigeons' dung operates, points out the manner in which it should be applied. As it is very rich, and its qualities soon exhausted, a very small quantity should be applied, in proportion to the quantity of other dung. If care be not taken of this, the crop will be destroyed by being too luxuriant. Perhaps mixing it with some other things may have good effects. The strewing small chaff of any kind, from time to time, on the bottom of the pigeon-house, is very proper. The chaff sucks up the moisture, and makes it easy to reduce the dung to powder, which is an advantage; for thereby the dung is scattered more equally, and manures a greater quantity of land.

It is a custom, in some places, to fold sheep and cattle for the sake of their dung; which, in this way, is used without any mixture. Some writers on husbandry give particular directions how to do this in the most advantageous manner. But it is needlefs to consider these. The farmer must consult the advantage of his sheep and cattle, and not the advantage of the land by the dung; and therefore must fold them in the most convenient manner. A score of sheep, with the best management in folding, will not produce much more than ten shillings worth of dung, in the season, above the expense of folding; a sum soon lost by an injudicious management of them.

ESSAY XXIII.

On Oil used as a Manure.

HAVING, for many years, considered oil as the great pabulum of plants, I was much hurt by the result of some experiments, which state oil as a *poison;* and turning this in my thoughts a thousand times over, it at last occurred to me, that though oil, as oil in its *crude* state, might act as a poison, yet it might be so changed as to convey it with great advantage to the soil, and I instantly recollected Dr. Hunter's mode by ashes; it also occurred to me that rape-oil cake, was known to be an excellent manure, that no objection had ever been made to it but its expensivenefs, and that if it was beneficial to the soil, it could only be so from the quantity of oil contained in it, though that quantity must be very small indeed, considering the procefs of first grinding the rape-seed, and the vast force used to drive out the oil, so that what remains is little more than a *caput mortuum;* yet the cake formed of these very remains, is known to be a rich manure.

Think for a moment from how many seeds, plants, shrubs, and trees, we draw oil; from rapeseed, linseed, mustard, fennel, aniseed, juniper, carraways, mint, olives, &c. Thus we evidently draw an immense quantity of oil from the earth, but when and how, do we convey any to it? I know of little or no attention paid to this circumstance in our compost dunghills, so that all the oil conveyed to them, can only be from animal dung.

Whatever may be the quantity of oil remaining in each *each* rape-cake, and I believe that no one will state it at half an ounce each, yet it must be remembered that after all it is only a *vegetable* oil; reflecting on this circumstance, and fully persuaded that *animal* oil, must be much superior to it, I directly went to town to inquire the price of whale or train oil, and there I was informed, that it was about 2s. 8d. per gallon; this I considered as too expensive, but pursuing my object, I was informed by Mr. Wilfred Reed, oil merchant, in Thames-street, that he could supply me with the bottoms or foots of oil, and a rich thick South Sea whale oil, at 14d. per gallon— This was the very thing I wished for, and directly ordered 60 gallons, for a five acre field, and thus went to work. Having a platform or bottom of twenty load of mould with eight load of dung on it, I carried on three load of light sandy mould, and one load of brick and mortar rubbish, ground fine, and having mixed these well, and made a kind of dish of it, about five feet wide and ten feet long, with a ladle we put over it one half of the oil—It was in August, and the warmth of the sun soon made the thick oil soak into this compost, when it was directly thrown up in a heap, broke down again, and by five or six turnings, well mixed together, and left in a heap two days, when it was spread equally over the whole dunghill; twenty load more of good mould was then carried on, eight load of dung, and the remaining thirty gallons of oil was mixed as before, in sandy mould, and brick and mortar rubbish, and equally spread over, and the whole was covered by trimming the four sides of the dunghill, and throwing it on the top.

Thus the dunghill lay more than two months, when it was cut down by mattocks, carefully broke, well mixed, and turned over. The end of March it was carried on the field, spread, and ploughed in; it lay about a fortnight, was then ploughed again, and on the 22d of April last, it was drilled with the Rev. Mr. Cooke's most excellent drill; I mean his last, with hoes and scarifiers, which I think much superior to his former one: the last I think every farmer, who has seen it at work, will consider as incapable of further improvement. The field was drilled with barley, two bushels to the acre; the crop came up in a most even and beautiful manner; every seed was up within forty-eight hours of each other; all was ripe at the same time, and, from a couple of months after seed-time to harvest, was rated by all who saw it, and it was seen by many, as a sixty bushel crop.

At harvest, three rows were cut acroſs the field, directly thrashed and measured; one load out of thirteen was also thrashed and measured, and both stated the crop to be sixty bushels; but to wave all poſsibility of dispute or doubt, I am content to state the crop at seven quarters per acre.

As to the quality of the barley, I could here cite the opinion of one of the most eminent brewers in London, who saw the crop growing, and declared he would readily give 1000l. to be afsured that all the barley crops in the kingdom were of equal burthen and weight; five quarters of it have been lately sent to Nethrapps, in Norfolk, as seed-barley, under the denomination of 15 comb-barley; and an eminent maltster tells me it weighs 220lb. per sack, or 55lb. per bushel, Winchester measure.

Among the many gentlemen and farmers who saw the crop on the ground, was the celebrated Mr. Bakewell; he came with three or four others, and walking down the field, observed the hedge and bank; the bank, upon being touched with a stick, run down as sand and gravel generally do, and Mr. Bakewell being asked his opinion of the value of the land, if I do not mistake, valued it at 18d. per acre, but turning to the crop, and desiring his friends to do so also, he admitted that it seemed as if growing on land of 15s. or 20s. per acre.

I must not omit saying that the barley followed oats, upon a lay of six years old, that the land was, as is too common in such cases, much infested with the little red or wire worm, and that the oats suffered much from them; when we were ploughing for the barley the first time, I observed many turned up by the plough, when a distant ray of hope instantly darted upon my mind, that the oil in its then state, or from its strong effluvium, might prove obnoxious to them, and I am happy in saying, that the barley did not suffer from them in the least.

I can, however, add here, that I am now trying that experiment in Hampshire, having last autumn made up a dunghill, with twenty gallons of oil, on one-third of it, for a six acre field, which is now drilled with pease.

It is well known that all animal-substances, in a state of corruption, wonderfully promote vegetation, and are the actual food of plants.

The whale-oil which I used, is an animal substance, perhaps the richest part of the animal; whether I used enough, or what is the proper quantity per acre, experience must point out. Say I used eight loads of mould, three or four loads of dung, and twelve gallons of whale oil, per acre.

That oil applied to land, as a food for plants, in its crude state, acts as a poison, I cannot deny, but my procefs is very different; I believe that oil, particularly animal oil, is the pabulum of plants, that is, oil subtilized by the salts in a compost dunghill, left there a considerable time, in a state of putrefaction, and until the whole is become putrescent, *then*, I say, I *believe*, I have got the best and richest manure that can be carried on land.

The barley evidently proved its excellence; a ridge of summer cucumbers, in my garden, pointed out to many its great power, the leaves being in general, from ten to ten and a half inches broad, and the vines occupied an uncommon space of ground. Five hundred cabbages and savoys, planted by the side of four thousand more, and which had only one handful of the oil manure put into each hole made by the dibble, at the time of planting, were evidently near as big again as the others.

ESSAY XXIV.

On Top-drefsings.

SOOT, malt dust, pigeon dung, and rape-dust, are considered as top-drefsings. They are never worked into the land by the plough. In that, they efsentially differ from other manures. The theory of top-drefsings is not generally known; the practice, consequently, is but imperfectly understood.

When any kind of manure is worked in by the plough, we mean to lighten the soil, and at the same time to fill it with nourishing particles. But, when we apply top-drefsings, we only consider the nourishment of the plants, having no regard to loosening the earth. Light, sandy, and lime-stone lands are best managed by top-drefsings. Stiff loams and clays require lime and rotten dung to break the cohesion of their parts. The one remains in the ground for the benefit of succeeding crops; the other is only the food of the year. The tillage-farmer, whose soil is thin, should pay a careful attention to top-drefsings. They are the soul of his husbandry. On the lime-stone lands in Yorkshire, rape-dust is chiefly used ; but the price is so much advanced, that the farmer can hardly afford to purchase it. An acre of wheat land cannot be well drefsed with lefs than four quarters of rape-dust : three quarters are sufficient for an acre of barley. The price is about eighteen shillings per quarter. To obviate this great expense, I shall recommend a compost made of shambles-blood and saw-dust, which I have found experimentally to equal, if not excel, most hand drefsings. This compost has the peculiar property of being no way offensive to the smell. It comes cheap, and may be procured in every large town. I cannot give any directions relative to the quantity necefsary for drefsing an acre of land. My experience upon it has been confined to a small scale.—It is speedy in its effects, but not lasting.

In Flanders, where manures are well understood, they dry and powder human ordure, which they use as a top-drefsing, and find it of a rich quality. In large manufactories, and in places where a number of people live together, it may be a judicious practice to receive all excrementitious matters upon saw-dust; which, by frequently turning over, may be converted into one of the richest drefsings.

In order to have a distinct idea of top-drefsings, we must reflect that wheat, oats, barley, and rye, have two kinds of roots. The one is called the *seminal*, the other the *coronal* root. The first lies deep in the ground, and proceeds immediately from the grain: The other is formed just within the surface. In proportion to the vigour of this last, the crown becomes stronger or weaker; or, in other words, the plant tillers more or lefs. In winter corn, the plant is nourished, during the severe months, by the *seminal* root only. It should therefore be placed pretty deep, to secure it against the effects of the frost. On this account drill-wheat stands the winter better than the broad-cast. The *coronal* root seldom appears before the beginning of March. This is therefore the season for the application of top-drefsings. The first shower of rain washes them just within the surface, where they become the immediate nourishment of the *coronal* root.

In most places, rape-dust is harrowed in with the winter corn; but soot is always laid on in the spring. By the application of this last, the plants soon recover the injuries of the winter, and a large crown is formed, from which a number of stalks are produced in proportion to the size of the crown.

In spring corn, the *coronal* roots form themselves within a few weeks after sowing; for which reason the top-drefsings should be harrowed in with the grain.

It will be necefsary to remark that, as top-drefsings can only operate but a little way within the surface, they are therefore only proper for horizontal feeders; as wheat, oats, barley, and rye. Beans, and tap-rooted plants require such manures as are worked into the land by the action of the plough.

It may be objected that turnips, though tap-rooted, yet receive benefit from top-drefsings; but it must be considered that they operate upon the plant by pushing it hastily into rough leaf, and thereby securing it against the fly. After this, the turnip flourishes or declines in proportion to the richnefs or poverty of the soil.

So much depends upon the right use of manures, that we cannot employ too much time in investigating their natures. Notwithstanding what Mr. Tull and other ingenious gentlemen have advanced, I am clearly of opinion that manures are the life and soul of husbandry. Till the farmer can scientifically explain the manner that manures operate, he will find it impofsible to reduce his profefsion to the standard of reason. I therefore flatter myself, that, from these efsays, he will be able to collect some hints that will be of use to him in forming a just notion of one of the most important branches of agriculture.

BOOK II.

ESSAY I.

On the different Quantities of Rain which fall at different Heights over the same Spot of Ground.

EVERY operation of nature, which influences vegetation, is interesting to the speculative and philosophical farmer. The discharge of the ELECTRICAL FLUID, by the descent of rain, may be considered as a primary agent in producing the germination of seeds, and the rising of the sap in vegetables. Electricity accelerates the motion of the fluids in the capillary tubes of plants, increases their perspiration, heightens their verdure, and powerfully promotes their growth. Hence perhaps, in some degree, arises the *instantaneous* vivifying effect of a summer shower on the vegetable creation.

It is hoped, therefore, that the following attempt to account for the different quantities of rain which fall at different heights over the same spot of ground, will not be deemed entirely foreign to the purpose of these efsays.

In the last volume of the Philosophical Transactions, some experiments are related, by which it appears, that there fell below the top of a house, above a fifth part more rain than what fell in the same space above the top of the same house; and that there fell upon Westminster-Abbey not above one half of what was found to fall, in the same space, below the tops of the houses*. These ob-

* I am informed by an ingenious correspondent at Bath, that similar experiments have been made in that place with the same result; and a friend of mine at Liverpool, on whose judgment and accuracy I can rely with confidence, has lately favoured me with the following account, dated March 14, 1771: "During the late rains I repeated Dr. Heberden's experiment: The upper vefsel received thirteen ounces and a half of rain, the lower vefsel twenty-seven ounces. The difference of altitude was about sixteen or seventeen yards. The wind blew a brisk gale from the south-east. I made the trial also during a fall of snow: and, in that, found the proportion as three to five." The following experiment, communicated to me by the same gentleman, varies a little in its result from the former, owing, perhaps, to a difference in the serenity of the air: for the wind has a more powerful effect on the descent of snow than of rain, because its specific gravity is lefs.—

servations, however new and singular, are too well authenticated to admit of the least degree of doubt; and philosophy should be employed not to invalidate a fact so fully ascertained, but to furnish a rational and adequate cause of it.

Dr. Heberden conjectures that this phænomenon depends on some property of electricity, which he thinks remains hitherto unknown. To me it appears probable, that the common laws by which this power influences the ascent and suspension of vapours, are sufficient

"March 27, 1771, there was a continued fall of snow, from eight in the morning till five in the afternoon. The air was still; the snow came down very thick, and in large flakes. During the nine hours which the snow continued to fall, the upper vefsel received thirteen ounces, the lower vefsel twenty-six ounces." In the years 1773 and 1774, the observations on the different quantities of rain, which fall at different heights, were repeatedly made at Liverpool: and it was almost invariably found, that a vefsel, standing on the surface of the ground in a spacious garden, received *double* the quantity of rain which fell into another vefsel of equal dimensions, placed near the same spot, but eighteen yards higher. At Middlewich, during part of the year 1774, the quantity of rain caught at the top of the church-steeple was 15,75 inches; and in a garden, eighty feet below, 19 inches. The garden, it should be remarked, was not contiguous to, although at no great distance from the church.

to explain their precipitation in rain, and the lately-discovered mode of its descent.

The electrical fluid is ſtrongly attracted by water, and by destroying the cohesion between its particles, and repelling them from each other, it becomes a powerful agent in evaporation. The waters of the ocean abound in this fire, and vapours raised from them float in the air, forming clouds which retain their electricity, till they meet with other bodies, either destitute of it, or containing it in a leſs proportion than themselves*. This, in all probability, is frequently the case with those vapours or clouds which are produced by exhalations from the earth, from fresh water, and the perspiration of plants and trees; at least it is an undoubted fact, that some clouds (to use the language of this branch of philosophy,) are electrified positively, and others negatively. No sooner does the communication take place, but the repulsion between the particles of water is diminished, those which have discharged part of their electricity, are succeſsively attracted by the contiguous ones which have not; and thus

* Vid. Franklin on Electricity.

they prefs nearer together, become specifically heavier than the atmosphere, and descend in small drops, which, losing every instant more and more of the electric fire, coalesce, uniting into larger and larger drops, and consequently filling a space which is continually diminishing, as they approach nearer to the surface of the earth. This may be illustrated by electrifying the stream of a fountain, which will spread itself into the form of a brush by the mutual recefsion of the particles of water: but withdraw the supply of electric fire, and the fountain discharges itself in one continued current*. A pair of cork-balls suspended together by silken threads, when electrified, recede from each other; and if the air be dry, return by degrees only to their natural position. Two feathers electrified will float in the atmosphere, mutually repelling each other, when in a certain degree of contiguity, and gradually descending as they lose that power, which, by expanding their *plumulæ*, rendered them specifically lighter than the air. But if one of them discharges suddenly the electric fire, it will instantly be attracted

* Vid. Franklin on Electricity.

towards the other, and receive a fresh supply; when a repulsion (acting indeed at a much lefs distance than before,) will again take place between them.

When two clouds, one replete with electric fire, the other destitute of it, come within the sphere of each other's attraction, they will rush together, and the electrical fluid being diffused through a larger space, the particles of water will unite, and form themselves into drops of greater magnitude, and a heavy shower will be produced. Still, however, as the rain descends through an atmosphere containing little electric fire, it will be continually communicating it; and the discharge being greatest from the circumference of the cloud, because the surface is there largest, the drops will be drawn nearer and nearer to each other, and, approaching towards one common centre, will gradually coalesce in their pafsage.—Dr. Franklin has related a most ingenious experiment, which elucidates the formation of rain as thus described. Take two round pieces of pasteboard of two inches diameter; from the centre and circumference of each of them suspend, by fine silk threads eighteen inches long, seven small balls of wood, or seven peas equal in bignefs, so will the balls appending to each pasteboard, form equal equilateral triangles, one ball being in the centre, and six at equal distances from that, and from each other; and thus they represent particles of air. Dip both sets in water, and some adhering to each ball, they will represent air loaded. Dexterously electrify one set, and its balls will repel each other to a greater distance, enlarging the triangles. Could the water, supported by the seven balls, come into contact, it would form a drop or drops so heavy as to break the cohesion it had with the balls, and so fall. Let the two sets then represent two clouds, the one a sea cloud electrified, the other a land cloud; bring them within the sphere of attraction, and they will draw towards each other, and you will see the separated balls close thus: the first electrified ball that comes near an unelectrified ball, by attraction joins it, and gives it fire; instantly they separate, and each flies to another ball of its own party, one to give, the other to receive fire, and so it proceeds through both sets, but so quick as to be in a manner instantaneous. In their collision they shake off and drop their water, which represents rain. This experiment would better illustrate and confirm my *hypothesis*, if a larger number of balls were appended at equal distances, to each pasteboard, so as to form several circles, having one common centre.

But it rarely happens that a land cloud is equal in magnitude to one raised from the sea; consequently the rain produced by their union will be proportionably lighter in the upper, and heavier in the lower regions of the atmosphere, as the electric matter is more or leſs gradually diffused.

When an electrified cloud, without mixing with another cloud, or losing part of its electric fire, becomes specifically heavier than the atmosphere, by cold, or some local change in the density of the air, it will descend at first perhaps in a mist; but will form, as it approaches nearer to the earth, and is leſs replete with the electric fluid, a light shower of rain.

Besides the clouds which float separately in the higher regions of the atmosphere, the air contains a large quantity of water in the state both of solution and of diffusion; and dews, fogs, and sometimes even showers of rain, are probably produced by the precipitation of the water thus suspended. Now the quantity of water which the air is capable of dissolving and suspending, is proportioned to its degree of density; and this density decreases in a certain ratio, according to its distance from the surface of the earth. Rain, therefore, in its descent will be every instant acquiring an accession to the bulk of its drops, by attracting these aqueous vapours. For the cold produced by a falling shower, will precipitate from the air, both its dissolved and diffused water. And thus, at different heights, will be produced, from this cause, some difference in the quantity of rain which falls over the same spot of ground. The discharge of the electrical fluid from a falling shower, may also act as a powerful precipitant of the vapours, which are chemically dissolved in the air. For by conveying an electrified wire to the surface of a quantity of water, saturated with any saline substance, an immediate and copious precipitation is produced, and the salt forms itself into large *flocculi*.

Rain, when undisturbed by winds, descends in lines converging towards the centre of the earth, like the *radii* of a circle. This direction towards the perpendicular, however trifling in degree, gives some little tendency to the drops to coalesce together, and concurs in the general effect of producing a different quantity of rain at different heights.

From what has been advanced, it appears probable to me, that the gradual discharge of the electrical fire is the principal cause of the phænomenon I have attempted to explain. As the rain descends, the drops coalesce more and more together, by the continued diminution of the repulsive power which counteracted their mutual attraction; and consequently, in a given space, a much larger quantity will fall near to, than at a distance from, the surface of the earth. A cloud which fills many thousand acres in the higher regions of the air, when the electric fluid operates upon it with full force, may not cover one-third of that extent when it has descended in a shower of rain. To this effect the precipitation of the vapours contained in a difsolved or diffused state, in the lower regions of the atmosphere, and the influence of gravitation in producing a convergency of the drops of rain, will in some degree contribute.

P. S. Having communicated the preceding paper to Dr. Heberden and Dr. Watson, I have been favoured by the latter with the following curious fact.—" The water in the rain-gage at the top of Lord Charles Cavendish and Dr. Heberden's houses, which are about a mile distant from each other, pretty nearly correspond; but at the botton of Lord Charles's house, though the level is forty feet above the top of Dr. Heberden's, the quantity always exceeds that of Dr. Heberden's. Last year, for instance, at the top of both their houses, there were collected about twenty-two inches of rain; but in Lord Charles's garden, at a distance from any buildings, there fell twenty-six inches; and this, in his Lordship's garden, has been constant for several years. Dr. Heberden has been too much confined to make accurate observations at the bottom of his late house; but he is now removed to Pall-Mall, where his opportunities of observing are more favourable."

This fact, at first sight, appears to be a strong objection to the *hypothesis* I have advanced. May it not, however, be obviated, by supposing that the discharge of the electrical fluid from a falling shower, is not so much influenced by the absolute, as by the relative height of the places where the rain descends? And as the earth may be considered as the great recipient and attractor of electrical fire, is it not probable that the quantity of rain collected will be proportioned to the distance of the receiver from the ground immediately below, and not to its absolute height, measured from any distant level, except in such altitudes where the density of the air, and the vapours floating in it, are so far diminished as to produce a sensible variation? But I offer this conjecture with diffidence; and am sensible indeed that the whole of my attempt to account for the different quantities of rain, which fall at different heights, is liable to objections, because the *data* are yet few upon which it is founded. To promote the solution of so curious a phænomenon, I shall here subjoin a few queries, proposed to me by different correspondents. The fourth should, I apprehend, be reversed, because it appears probable to me, that trees, plants, water, and moist earth, afford more copious exhalations than paved streets, houses, burning fuel, or the bodies of men.

1. Does a glafs funnel catch an equal quan-

tity of rain, at the same height, as a metal funnel; the former being an electric, the latter a non-electric*?

2. Is there a difference in the quantity of rain and snow catched in similar vefsels at different heights?

3. Is the difference of rain, catched at different heights, greatest at the beginning of a shower?

4. Is not this difference greater in large

* A very ingenious friend of mine, at Chester, has lately favoured me with the following experiments, which furnish a satisfactory answer to this query, and at the same time confirm the hypothesis I have advanced, by proving that rain contains, and discharges in its descent, the electrical fluid. Two vefsels of equal diameters, the one of glafs, the other of tin, placed at the same height, and within a foot of each other, varied as follows in the quantities of rain which they received: From April 15, 1771, to 29, the glafs vefsel received 0.954, the tin vefsel received 1.432. From May 5, to 30, the glafs vefsel received 1.630, the tin vefsel received 2.027. From June 1, to 28, the glafs vefsel received 2.144, the tin vefsel received 3.674.

The same accurate observer found, that in the months of June and July, 1771, contrary to the common course of nature, a larger quantity of rain was received in the cities than in the country, owing to the lower regions of the air being more loaded with watery vapours, which have been exhaled by fires, and from the human body?

5. Has the wind no share in producing the disparity observed in the quantities of rain which fall at different heights?

6. May not the column of air, through which a drop of rain pafses, in the space of twenty or thirty yards, contain a sufficient quantity of watery particles to double the

---

higher, than in the lower funnel. For instance, the rain caught in a vefsel placed at the top of St. John's steeple, from June 2, to July 1, amounted to 1.886, and from July 2, to August 3, to 1.423. Whereas a similar vefsel, placed in a garden below, received during the same space of time, only 1.404, and 0.452. This inverse proportion of rain, received at different heights, cannot be supposed to depend either upon chemical or mechanical principles, but may be accounted for by the same electrical laws, which have been adduced to explain the more usual phænomena of its descent. If the falling showers proceeded from clouds negatively electrified, the drops of rain would diverge more and more as they approached nearer to the earth, because, instead of communicating, they would receive some portion of electricity from the vapours floating in the lower regions of the atmosphere.

bulk of the drop? This may be illustrated by precipitating any saline substance from a saturated solution of it, contained in a cylindrical vefsel, and examining the proportional quantities of precipitate at different heights. Or, perhaps, it may be determined by the following experiment: Take a cylindrical glafs vefsel, four inches in diameter, and eight inches high; fill it with ice or snow, and place it in a warm room. A watery dew will soon be congealed upon its surface, which being committed to a nice scale, may probably be found to be equal in gravity to a drop of rain. Suppose this cylinder to be drawn out to the length of twenty or thirty yards, the surface of it will still continue nearly the same, though the diameter of it be diminished; and such a tube will aptly represent the column of air through which a drop of rain descends in its pafsage to the earth.

ESSAY II.

On the Culture of Potatoes.

THE potatoe plant was first brought from America into Ireland by Sir Walter Raléigh. Though a species of the *Solanum*, or Nightshade, yet experience has most fully convinced us, that it is one of the best and most nutritious of all the esculent roots cultivated in this island. The great use and advantage of this vegetable, as a food, was never more happily experienced than four years ago, when an extraordinary crop*, both in quantity and quality, reduced the high prices of grain so much in this very populous neighbourhood†, as to give the poor an opportunity of buying bread upon more reasonable terms

---

* From an acre and a half, statute measure, I had as many potatoes as sold (at the low price of 1s. 3d. per bushel) for near 34l. besides serving my own family, (in which large quantities are consumed) and reserving a sufficient quantity for planting near two acres the year following.

† Rochdale.

than it was to be had in many of the most considerable corn counties of the kingdom.— I therefore flatter myself that it may be of use to point out the best methods that have occurred to me, not only of obtaining a large and good crop, but also of preparing the ground at the same time, and in the best manner, for a succeeding one of wheat. An object of no small importance to the farmer.

In the first place, I shall mention the kind of soil that is the best and most proper for the culture of this excellent root. The potatoe plant will indeed grow in almost any soil; but the mere growth of the plant, or the poor return of a few small and insipid roots, are not worthy the care and attention of the farmer.

The soil which I would prefer above all others, for this plant, is the same which Columella recommends for vines: *Nec spissum sit nimis, nec resolutum, proprius tamen resoluto; nec exile nec lætissimum, tamen læto proximum; nec campestre nec præceps, sed potius edito campo; nec siccum nec nimis uliginosum:* that is, the soil should neither be too stiff and untractable, nor too light and crumbling, yet rather of the crumbling kind; neither too poor nor too rich, yet inclining to richnefs; neither too flat nor too hilly, but rather gently rising; neither quite dry nor yet surcharged with moisture. With such a soil, and proper management, a noble return may be expected; and the nearer any soil approaches to the nature and qualities above recommended, the more proper and suitable it will be for the cultivation of the potatoe plant. But even from soils, not blefsed with all those desirable qualities, very beneficial crops may be obtained, if a little more labour and pains are bestowed upon the necefsary operations.

The different ways of preparing the ground for this crop, (which are either by ploughing, trenching, or common digging) are so well known in all, or most parts of the island, that it would be uselefs, as well as impertinent in me, to give any directions on that head. I will only give it as my opinion (founded on some experience) that when the ground, intended for a potatoe crop, is not of any great extent, trenching (though the most expensive) is far preferable to the others, and will generally more than repay the additional expense.—

I will venture also to condemn the common Irish way of planting, which is known and used in some parts of the kingdom, and is properly denominated the lazy-bed way. In this method the eyes, or sets, are placed upon the surface of the ground, with a little dung under them, and then a deep trench is made on each side, with the earth of which the sets are covered. By this horrid practice a barren, and perhaps noxious under-stratum of earth or rubble is thrown up so high as never to get covered again, but remains there as a woful exchange for some of the finest mould, that is buried beneath the reach of the plough.

I shall now endeavour to point out the best method of planting the sets, both for the present crop, and also for a due preparation of the ground for a succeeding one of wheat.

The sets (with one good eye, or two at most) should be planted in rows two feet asunder at least, if the crop is intended to be cleaned with the hand-hoe, and at the distance of fifteen or sixteen inches from each other in the rows; after which the ground should be broke in with a rake or light harrow. After the plants are come up, the first growth of the weeds should be carefully observed; and, taking the advantage of a dry and hot season, should be cut down, both betwixt and in the rows, and the earth hoed up a little towards the roots of the plants. The weeds being checked in their first shoot, and in such weather, will be long before they make any considerable head again. About midsummer it will be necefsary to go over the ground once more with the hoe; and if the advantage of a dry and hot season can then be taken, it will generally be sufficient to keep the land clean and free from weeds for the remainder of the summer, as the plants will then be grown so strong and bushy, as nearly to cover the whole surface of the ground; and therefore, by their shade and dropping, will prevent any future growth of weeds.

These stirrings by the hoe will keep the land in proper tilth, and kindly dispose it to receive the benign influence of the sun, air, and dews; and the intervals betwixt the rows of the plants will also allow due admifsion to the air, so absolutely necefsary for vegetation. "The air," as Bishop Berkley observes in his Siris, "is the receptacle as well as source of "all sublunary forms, the great mafs or chaos "which imparts and receives them. The at-"mosphere which surrounds our earth, con-"tains a mixture of all the active volatile "parts of all vegetables, minerals, and "animals. Whatever perspires, corrupts, or "exhales, impregnates the air; which, being "acted upon by the solar fire, (here is literally "*conjugis in gremium lætæ descendit)* pro-"duceth within itself all sorts of chemical "operations, dispensing again those salts and "spirits, in new generations, which it had re-"ceived from putrefactions The air, there-"fore, is an active mafs, composed of number-"lefs different principles, the general source of "corruption and generation, in which the "seeds of things seem to be latent, ready to "appear and produce their own kind when-"ever they light upon a proper matrix. The "whole atmosphere seems alive; there is "every where acid to corrode, and seed to en-"gender, in that common seminary and re-"ceptacle of all vivifying principles."

That the free admifsion and circulation of air, are not only conducive, but also absolutely necefsary to a speedy and vigorous growth of plants, might be easily proved by many experiments; but it is too obvious to every one, who has taken the least notice of the operations of nature in the important work of vegetation, to need such proofs of its necefsary influence. Without some air, it is well known, vegetation would neither begin nor continue. Dr. Fordyce, in his Elements of Agriculture and Vegetation, says, that even roots require air; so that if a root is planted too deep, it will not grow on that account. He is of opinion also, that light is necefsary for the growth of a plant, but not so much as air.

Many growers of potatoes, from want of experience, are apt to imagine that the greater number of plants they have, the greater will be the increase. In regard to numbers it possibly may be so, but even that admits of a doubt. The true proof of the increase, or return, is in the weight and goodnefs of the crop, and not merely in the number of pitiful roots. In the common promiscuous and close way of planting, the stems of the plants are drawn up so high and slender, by their contiguity to each other, that they become weak and languid long before the proper time of perfecting their roots; a certain indication of a miserable crop.

The ground, as is observed by Mr. Tull, (to whom, not only his own country, but many others in Europe are so much obliged for laying a rational foundation for most of the modern improvements in husbandry) contains a certain quantity of *pabulum*, or food for vegetables, which, though it may be considerably increased by manures, has its stated bounds, its *ne plus ultra*. The same gentleman mentions an experiment that he made, which very fully proves the great advantage of planting the potatoe-sets at a considerable distance from each other, and also the very great utility of hoeing and stirring the soil well about them. " A piece of ground," says he, " was planted with potatoes, the greater part in the common way; but in one part (worse than the rest) they had been set at a yard distant every way; the rest of the ground was dunged; this poor part had no dung, but was ploughed four times in different ways, so that the ground was broken and stirred thoroughly every way about the potatoes. The consequence was, that though no dung was used here, and the plants appeared shorter than in the dunged part, yet the crop was greatly better than in the other part of the field. The roots here were all large; in the other part which was dunged, and planted in the common way, and also without such ploughing, they were so small, that the crop was scarce worth taking up."

Where great quantities are planted, hoeing with a small light plough will be necefsary for despatch, and will do very well, and in some respects better than hand-hoeing, as the ground will be more effectually stirred; but the weeds should be cleared at least once with the hand betwixt the plants in the rows; and care should be taken not to throw too great a quantity of earth upon the roots, as that would be almost fatal to the potatoes in every respect, but especially in the goodnefs of them. The plants in a healthy vigorous state will, by the *umbrageous* defence of their thick leaves and stems, sufficiently protect the roots from the too scorching rays of the sun, and even retain a due degree of moisture in the ground, without excluding so much of his *energetic* power as is necefsary for perfecting the great work of vegetation: but, if the roots are buried too deep, that cheering and vivifying power of the sun is so impeded in exerting its necefsary influence, that the roots never arrive at their utmost state of perfection.

If the potatoe-crop is intended to be drefsed both with the plough and the hand-hoe, two rows should be planted about the distance of eighteen inches from each other; but the intervals, or spaces betwixt each double row, should be at least four feet, or there will not be room enough for the plough to work, without injuring the stems of the plants. If the crop is to be cultivated with the hoe-plough only, then single rows are best, leaving a space, as above, of four feet at least betwixt every row. This is a very expeditious way of cleaning a crop, and will answer all the purposes of hoeing very well. The way of planting the sets for this last kind of cultivation is very expeditious, and is as follows:

The ground being laid level, and in fine tilth, a straight furrow must be made from one end of the field to the other, leaving a space of two feet wide betwixt it and the verge, or border of the ploughed land. A boy follows after the plough, with the sets in a basket, and drops one at every fifteen or sixteen inches. When that is done, the ploughman turns about, and throws the furrow back again upon the sets, then begins with another furrow, leaving the proper space betwixt; returns again as before, and so on till the whole piece of ground is finished. One man, with a plough and two horses, and two boys, (one to keep the horses in a straight line, and the other to drop in the sets) will finish a large quantity of land in a day. When the whole planting is finished, the ground should be levelled by harrowing acrofs.

This is the best method for dry land; but if the ground be moist, strong, or heavy, it should be thrown into ridges of four or five feet each, and the sets planted on the top of the ridges. The depth of the furrows also should vary according to the nature of the soil. If it be very dry and light, the furrows may be made five inches deep; if moist, heavy, or strong, not above three or four at the most.

Having given directions about the management of the crop, I shall now beg leave to offer my sentiments in regard to the best kinds of potatoes now cultivated in this neighbourhood, both for summer and winter use. For the former, I would recommend the early red and white dwarfs, and the flat white kidney, by some called the true Spanish potatoe: For the latter, the white rufset, the red rufset, the golden tag, the Irish dun, and the smooth winter white. Indeed for black earth, the Irish blue potatoe, and the old English reds, are the most proper; as they are very hardy, and have strong coats or skins, which make them bear moisture better than the other kinds. The white Lincolnshire potatoe grows very large, and is a most plentiful bearer; it is also well flavoured, though not equal to some above-mentioned. But the most extraordinary potatoe of all, for producing great crops, is the Howard or Buckinghamshire potatoe. Mr. Dofsie speaks of it as a very nutritious and agreeable tasted root, if sufficiently boiled. Its increase almost exceeds belief; on which account I shall venture to recommend it to the attention of those who plant potatoes as food for cattle and hogs; a practice highly to be approved.

Last year I planted four eyes, from one of those potatoes, in four different kinds of soil:

N° 1. A strong rich loam.
2. A light rich loam.
3. A good gravelly soil.
4. A sandy soil.

The produce:

N° 1.	———	34 lb.
2.	———	29
3.	———	19
4.	———	15

I shall now mention, in as concise a manner as pofsible, some other experiments I made last year, in order to ascertain what kind of manure is most agreeable or beneficial to the potatoe plant.

I had a small field which was laid down in lands of about five feet broad: I put the intended manures into the furrows, and then ploughed it in the common way, by which means the manures were thrown into the middle of all the new lands, and upon which I planted the sets. The rows were all exactly of the same length; the very same quantity of sets in each row; and all had the very same advantages of hoeing:

N° 1. Manured with coal ashes only.
2. Stable-dung and coal-ashes mixed.
3. Stable dung alone.
4. No manure.
5. Compost made of dung lime, and soil.

N° 6. Stable-dung covered with common yellow mofs.
7. Soaper's waste.
8. Stable-dung and lime.
9. Lime alone.
10. Coal-ashes and lime.
11. Stable-dung and soaper's waste.
12. Soot, soil, and coal-ashes.
13. Salt and soil.
14. Saw-dust and coal-ashes.
15. Stable-dung and saw-dust.
16. Dung of poultry and coal-ashes.
17. Dung of poultry and sand.
18. Saw-dust and lime.
19. Decayed rushes and lime.
20. Tanners' bark and lime.
21. Bark and stable-dung.
22. Bark alone.
23. Stable-dung, with lime spread over the land.
24. Chopped whins, with a covering of lime over them.

The produce.

N° 1. 211 lb. rather small in size.
2. 344 lb. very fine.
3. 315 lb. ditto.
4. 134 lb. very small.

N° 5. 204 lb. middling size.
6. 438 lb. remarkably fine.
7. 383 lb. very fine.
8. 268 lb. tolerably well sized.
9. 187 lb. ditto.
10. 192 lb. ditto.
11. 298 lb. very good sized.
12. 271 lb. ditto.
13. 200 lb. ditto.
14. 190 lb. smaller in size.
15. 307 lb. very fine.
16. 236 lb. pretty fine.
17. 156 lb. rather small.
18. 197 lb. ditto.
19. 208 lb. very good ones.
20. 76 lb. very poor ones.
21. 144 lb. rather larger.
22. 35 lb. very poor.
23. 232 lb. pretty fine ones.
24. 256 lb. very fine and large.

I can only say in favour of this account, that it is very accurate. I saw the potatoes taken up and weighed, and also entered them (upon the field where they were weighed) into my memorandum-book, from whence the above account is taken. Many will be surprised at the apparent advantages arising from the use of whins and mofs. The former I had known tried before, and with fuccefs, in the culture of potatoes; and the latter I found ranked at the head of a clafs, termed the *fattening manures*, in a periodical work, published at Paris under the title of *Journal Œconomique.*

As stable-dung and mofs seemed, from the above experiments, to have the advantages over all the rest, I was determined to make a fair trial of their respective merits. Accordingly I had two rows of potatoe-sets planted alternately upon stable-dung and mofs, so that there could be no advantage, either from soil, exposure, or cultivation, to one plant more than another. I had one row dug up in my presence, and immediately weighed. The consequence was, the crops were so equal in weight, that the balance could not determine the difference. Those that came from the dunged plants were more in number, the others better and more equally sized.

The last experiment was made upon some seedling potatoes, called the *Ogden Seedlings*, raised the preceding year from one of the forward kinds. They promife much, both for goodnefs and perfecting their roots very early. All our varieties have been procured from the seed, and more may be expected: This is certainly the best method to keep our present sorts from degenerating.

This year I took up one row of potatoes, part of which was manured with stable-dung and coal-ashes, the other with the same quantity of stable-dung and mofs. The consequence was, that those from the dung and mofs, not only exceeded the other in size, but were about a third more in weight. The soil and cultivation the same.

Many inferences may be deduced from the above experiments, some of which are very obvious; as that mofs is a very good manure for potatoes; stable-dung very good and proper; coal-ashes the same, but not equal to the former; soapers' waste a very good one, but it is too dear, as well as difficult to be obtained in large quantities.

ESSAY III.

On the Analogy between Plants and Animals.

IN a former efsay, the laws of vegetation were plainly discovered to be analogous to those maintained throughout the animal world. And if we extend our inquiries, we may trace the connection so far, that it would be difficult to determine where it ceases.

It is amazing to observe the infinite wisdom of the Creator in his works, and the entire dependence which one part of them has upon the other. We, who at best can only reason from second, and those very imperfect causes, must necefsarily stand amazed whenever we contemplate the works of the creation.

It is our duty, however, to extend all inquiries, which are subservient to the advantage of society, to the highest pitch of perfection in our power. The study of nature can never be sufficiently attended to. Nor can agriculture be ever brought to perfection, till a just theory be drawn out from the walk of nature herself. She is so bountiful to us, that her treasure is never exhausted; and the more discoveries we make, the more we find intirely unknown to us.

It is true the vegetable world is a very passive one. The want of sensation, and the means of self-preservation, render it essentially different from the animal world. In most other points, the image of the one may be distinctly traced in the mirror of the other. They have a code of laws drawn up for them by the Author of Nature himself, and to it they steadily adhere.

It need scarce be remarked, that nature observes her stages and periods of life, in the vegetable, as well as in the animal world. We observe the greatest tenderness and delicacy in the first growth of every plant. Their maturity wears every mark of health and vigour: and this is the period for produce and increase. Vegetables, as well as animals, afford strong evidences of the decline of life. When nature has run its course, we observe the brawny oak gradually decay: hoary old age tumbles it into ruins, and *the place thereof knoweth it no more.*

Some plants are of longer duration than others. Annuals, Biennials, Perennials may all be observed within a very narrow compafs of ground. Some produce flowers but once in the time of their existence, and then exhaust their own life in giving it to their offspring. One revolving sun often measures the duration of other flowers, particularly the Ceres, which, like children, frequently come into the world, as it were, but to try to live.

We certainly may imagine, with great truth, that plants have few offices to perform. And yet nature has afsigned them more than we are aware of, for our use as well as instruction. The story of the sun-flower in Ovid's Metamorphoses, is confirmed by daily observation. Thomson beautifully describes its affection:

> But one, the lofty follower of the sun,
> Sad when he sets, shuts up her yellow leaves,
> Drooping all night; and when he warm returns,
> Points her enamour'd bosom to his ray.

Most of the discous flowers, by some elastic power unknown to us, follow the sun in its course. They attend him to his evening retreat, and meet his rising lustre in the morning with the same constant and unerring law.

Vegetables enjoy their periods of sleep and rest equally with the animal world. The common goat's-beard seems designed to remind us of the sun paſsing the meridian, by closing up its flowers at that time; whilst all the trefoils serve as a barometer to the husbandman, by constantly contracting their leaves against an impending storm. I need scarce mention the contracting qualities of the tamarind, acasia, sensitive plant, the common whitlow-graſses, and cuckoo-bread, to strengthen my aſsertions. They are facts sufficiently known to mankind in general.

In the animal world we observe, that many creatures undergo various changes during the course of their existence. The caterpillar, in particular, undergoes several changes before it produces a butterfly. The very same effects may be traced in the vegetable world. Who could imagine, without knowing the fact, that ivy, in its infant state, bears lanceolated leaves, and produces neither flowers nor fruit? In its next state the leaves are quinquelobed, and the plant adheres, in a barren state, to trees and rocks for support. Three years generally elapse, like a peacock in getting his plumes, before it branches out into a tree, with trilobed leaves, and produces both flowers and fruit. And it is still as wonderful to observe that it finishes its growth with plain oval leaves.

Diseases are as incidental to plants as animals. The amputation of a limb, or the loſs of it by the violence of a tempest, spoils the symmetry of the plant, and retards its growth. The vine bleeds too much if it be pruned by an unskilful hand, or at an improper season. The orchard refuses its crop of apples, if we use the knife frequently or improperly.—Canker, on another hand, corrodes the very vitals of existence. And nothing is so common as to see insects and vermine destroy the most vigorous shoots. Exceſsive drought, or intense cold, and above all, an improper soil, shoot the arrows of certain death. We readily allow that an inhabitant of the Torrid Zone would soon be starved to death in Greenland or Lapland: But we forget that the same wise

Creator of all things, has also appropriated a proper soil and climate to the simplest weed that grows.

ESSAY IV.

On Experiments.

EXPERIMENTS correctly made, and fairly related, form the data on which agriculture should be founded. To plan an experiment well, to trace it minutely through its progreſs, and to draw a just conclusion, is expected from the philosopher. And yet experiments that spring from chance more than reason, should not be neglected. The following experiments, with some short pieces of practical information, have been transmitted to me. Their authenticity and correctneſs sufficiently recommend them.

EXPERIMENT I.

On the Oil-Compost.*

In the month of June I selected four lands, of equal goodneſs, in a field intended for turnips. The soil was a light sand, with

* By A. Hunter, M. D.

a small portion of vegetable earth amongst it. It was ploughed out of sward in November, and had not borne a crop for many years. I shall distinguish my experimental lands by Nº 1. 2. 3. 4.

Nº 1. was manured with rotten dung.
2. with oil-compost.
3. with lime.
4. was left without any dreſsing.

On the 20th of June they were all sown with turnip-seed, broad-caſt, and during the course of the season were twice hoed.

In November I viewed the field, and made the following remarks:

Nº 1.—the best
2.—the next.
3.—the worst.
4.—better than Nº 3.

Here the oil-compost appears in a favourable light; but other trials, made with equal accuracy, seem rather to prove that it is not proper for turnips, barley, or quick-growing vegetables. It requires being meliorated by the action of the atmosphere, and therefore is better adapted to winter crops. By repeated experiments made since the publication of the first edition of this efsay, I am convinced that the addition of an alkaline salt is not sufficient to alter the nature of oil, so as to make it fully capable of entering into the roots of plants in its native form: But when decomposed by the mixture of fresh dung, I am convinced that it then becomes the true pabulum of plants. The farmer considers carbone as giving to " airy nothing a local habitation and a name."

When the land happens to be stiffer than is required for turnips, it may be good husbandry to lay upon it a large quantity of lime to open its body for the free admifsion of the tap-root of the turnip. The lands will also be rendered more dry, without which the turnips will never arrive at any size. Farmers, in general, take great pains to pulverize their light soils intended for turnips; but they seldom plough deep enough. A turnip is found to root deep, and in all operations of husbandry we should be careful to follow the bias of nature. It is for that reason we ought to make ourselves acquainted with the size and shape of the roots of such plants as are objects of field-husbandry. When once we have obtained that necefsary knowledge, it will be an easy matter to suit the preparation of the soil to the nature of the grain. It will also enable us to direct the variations of our crops upon just and rational principles.

It is abundantly evidently that all plants live upon the same food. Some require more, some lefs. Some take it near the surface, others take it deeper. Upon these principles we may account for the necefsity of varying the crops in the old husbandry. The old drill husbandry makes all change of species unnecefsary. In it all kinds of grain may be suited to the lands most proper for them. The succefs of that sort of husbandry, when properly conducted, proves to a demonstration that all plants are nourished by the same food. That food, I apprehend, consists chiefly of oily and mucilaginous particles.

It is of great moment to fix upon what is really the nutriment of vegetables, as it will enable us to conduct our compost dunghills upon just and rational principles. The doctrine of manures is but little understood. The farmer should at all times retain in his memory a general idea of them. He may divide manures into four kinds.

1. Such as give nourishment only; as rape-dust, soot, malt-dust, oil-compost, blood-compost, pigeon dung, and all hand-dressings.

2. Such as give nourishment, and add to the soil; as horse dung, cows dung, human ordure, rotten animal and vegetable substances.

3. Such as open the soil, and do not nourish in their own nature; as lime, light marls, sand, and vegetable ashes.

4. Such as stiffen the soil, and at the same time nourish a little; as clay, clay marls, and earth.

An attention to these general remarks, and a few observations upon the openness, stiffness, and depth of the different soils, will enable the farmer to lay down a rational system of cultivation

The theory of Agriculture being but little understood, it is no wonder that the practice has remained for ages, so vague and uncertain; but I flatter myself that the time is advancing when the husbandman will vie with the gardener in the rationality of his employment.

II.

*On Manuring Meadow Lands**.

It is a general practice for the farmers in the southern counties to manure their meadow lands at Christmas. We, on the contrary, put it on as soon as pofsible after the sithe. I have made a number of trials with a view to determine the merit of each respective way, and dare venture to say that it is better to manure when there is some life in the grafs, than at a time when all vegetation is stopt.

The southern farmers alledge, that the volatile parts of the dung may, during that hot season, be exhaled by the sun. I grant that this objection may have some weight; but it must be considered that rain frequently falls

* By Mr. T. Bond, of Heworth, near York.

at that season of the year, a small quantity of which will be sufficient to wash the dung amongst the old roots of the grafs, which, by shading it from the rays of the sun, enables it to preserve its vigour. This effect is the more readily accomplished, as we constantly employ a heavy bush-harrow to spread the dung equally upon the ground. By following this method, our aftermath generally becomes luxuriant. Besides, it more effectually encourages the shooting of the young grafs in the spring. The roots of all perennial grafses renew themselves by off-sets, and die after they have perfected their seed. The manure, when laid to the old roots, invigorates the off-sets, by keeping them warm during the winter. Lands manured after the sithe, are not so easily frozen as those which have not been drefsed in that manner. This is an undoubted fact, and proves greatly in favour of the northern husbandry. After very severe winters, the young grafs that should have branched out from the old roots is frequently killed. The seeds also which were shed in July, being young and tender, are often destroyed. Our manner of drefsing affords them a certain protection in the severest seasons. It may be objected, that dung, laid on after the sithe, may render the aftermath disagreeable to the cattle. But our farmers do not practically find that inconvenience. Could we always be sure of a shower of rain within a few days after laying on the manure, our method would then, incontestibly, be the best; but, even without that certainty, I find it better than the other.

III.

*On a new Kind of Manure**.

All kinds of animal substances go into spontaneous putrefaction. Vegetables do the same; but to effect their entire dissolution, a greater degree of heat is required. I do not mean in this place to treat of the various manures made use of by the farmer. It would be carrying me into a field too extensive for my limited design. The first experiment contains some general remarks upon this head, which the intelligent husbandman may easily improve into a system.

The bounty granted by Parliament for the encouragement of the whale fishery, has been

* By A. Hunter, M. D.

the means of saving an immense sum to this nation. The Dutch used formerly to monopolize the trade; but by the wisdom of the legislature, we now enjoy a considerable share of it. In a former efsay, I have endeavoured to show that train-oil made into a compost with pot-ash, makes a good succedaneum for dung. A number of experiments, made by very accurate observers, seem to establish the opinion.

When the oil has been taken from the blubber, by the action of boiling water, the remaining part is thrown into the sea. I have long lamented that no person has ever considered this fatty substance in the light of a manure. It is an animal body, and, beyond all doubt, capable of being reduced, by putrefaction, into a rich food for vegetables. The only thing that remains, is to direct the farmer in the manner of its application.

In September, 1770, I collected about a ton of it, which I mixed into a heap with four loads of fresh horse dung. This spring I propose to mix it up with a proportionable quantity of such materials as are usually collected for forming a compost dunghill, and

I flatter myself that it will prove a rich and cheap compost. I do not take upon me to say that this is the best method of using the whale flesh. It will give me pleasure to hear that others have applied it differently, being well afsured that perfection can only be attained by the concurring afsistance of many. I boast of no other merit beyond giving the original hint. There was a time when the richest manures, produced in cities and large towns, were either conveyed into the sea, or thrown into rivers. We have now the satisfaction to see that method universally condemned.

In order to encourage the farmer to seek after the refuse of train oil, I might observe that no manure has hitherto been found of a richer quality than the putrid offal of fish.—In some parts of Cornwall they manure their lands with pilchards in a plentiful season, and find that no manure equals them in richnefs.

It is allowed on all hands, that putrid vegetables make good manure; but it should be remembered, that animal bodies, when reduced into the same state, act more powerfully, and preserve the land much longer in strength and vigour.

We cannot pay too much attention to every thing that relates to manures; without their afsistance the richest soils would soon be reduced, by frequent cropping, to a barren state. It is pleasing to observe how the difsolution of one body is necefsary for the life and increase of another. All nature is in motion. In consequence of the putrid fermentation that is every where carried on, a quantity of vegetable nutriment ascends into the atmosphere. Summer showers return much of it again; but part falls into the sea, and is lost. To this we may add the animal and vegetable substances consumed on board of ships, all of which are buried in the ocean. The industry of man restores them again, but in a different form; and we may presume that the fish taken from the sea, leave a balance in favour of mankind. Thus Providence, with the most consummate wisdom, keeps up the necefsary rotation of things.

IV.

*On the Oil-Compost**.

In the month of May I planted twelve alleys, that lay between my asparagus beds,

* By Mr. Roebuck, gardener, in York.

with cauliflower plants. Each alley took up about thirty plants. One of the alleys I set apart for an experiment with the oil-compost, which was prepared according to the directions given in the first volume of the Georgical Eſsays.

About a handful of the compost was put to the root of each cauliflower plant. In all other respects the alley was managed like the rest. The plants in general flowered very well; but those to which I applied the compost, sprung up hastily with small stalks, and produced very poor flowers.

I imputed this unfavourable appearance to the freshneſs of the compost, which was only a few weeks old. In all future trials, I shall expose it to the action of the air, in order to abate the heat, and neutralize the acrimony of the salt.

In the September following this unsucceſsful experiment, I planted the same alleys with early cabbages. The neceſsity of meliorating the compost, was in this trial fully confirmed. For the cabbages that grew upon the alley, which in May had received the compost, were larger, and in all respects finer, than the others.

The idea that I entertain of the compost is, that, when meliorated in the earth, it is capable of giving a richnefs and freshnefs to it. Upon this principle I would recommend it to gardeners as a subject worthy of further trials.

V.

On Siberian Spring-Wheat.*

On the 14th of April, 1770, I sowed three bushels and a half of the Siberian spring-wheat on an acre, and reaped it with the first wheat in the neighbourhood. I had thirty stooks, which yielded above three pecks per stook. The wheat weighed four stone six pounds per bushel.

VI.

On the Howard, or large Bedfordshire Potatoe†.

By all the experiments that have been made, the Howard potatoe is found to produce the

* By M. Dodsworth, Esq. of Craike Hall.

† By T. B. Bayley, Esq. of Hope.

largest crop. On that account they are chiefly used in feeding of cattle. In two beds, four feet wide, and two hundred feet long, I planted in a common field a sufficient number of sets of this kind of potatoe, and managed them by the horse-hoe. The produce was sixty-four bushels, each bushel, up-heaped, weighing about 70 lb. My cattle eat them boiled, with as much eagernefs as the best sorts, and came on as well with them. I have built a boiling house, &c. on Mr. Young's plan, and during this whole winter have boiled potatoes for my cattle. For the fattening ones, I mix ground oats with them; and for the milk cows, malt-dust; and dare venture to affirm that they are much more profitable than either turnips or cabbages. Once, when my potatoes grew low, I desisted giving them to the milking cows. Immediately, though fed with the best hay, they fell off amazingly in their milk. I therefore began again, and in a week's time they gave better than one-third more butter. I own this accidental discovery gave me much satisfaction, as it confirmed my opinion, that potatoes boiled are an excellent winter food for cattle. Their culture is not so difficult, at least not so precarious, as either turnips or cabbages. Their value is superior, and there is no risk of their giving a disagreeable taste either to butter or milk. Add to this the vast increase of the Howard potatoe, and its equality with the best sorts when used for cattle.

VII.

On the Increase of Potatoes.*

My gardener cut a large potatoe into nine pieces, which he planted with dung, in a drill, in the garden. By earthing up and laying the shoots, he produced 575 sizeable potatoes, which weighed 8 st. 8 lb. Another of my servants produced, in the field, 7 st. of good potatoes from the same number of sets. Though this experiment cannot always be executed in its full force in an extensive scale, it ought notwithstanding to be imitated as nearly as circumstances will allow. It shows, in the most distinguishing manner, the use of clean and careful husbandry.

VIII.

On the Increase of Potatoes†.

On the 14th of April, I cut a large white potatoe into seventeen sets, which were planted in as many hillocks, at the distance of

---

* By George Wilson, Esq. of Brough.

† By Mr. John Williams, near Coventry.

four feet. In the course of growing, the plants were earthed up, and upon the 14th of October the crop was taken up: The produce, ten pecks of sizeable potatoes. At the time that this experiment was made, I had several hillocks, in which I put three and four sets of the same kind of potatoe. But, upon the most careful examination, I could not observe that these hillocks produced a greater crop than the others planted with a single set.— Hence it is obvious, that the potatoe spreads its roots most kindly when least crowded.

IX.

*On the Oil-Compost**.

In the year 1769, I made the following trial with the oil-compost, which was prepared agreeable to the directions given in these efsays.

				Produce.		
	l.	s.	d.	q.	b.	p.
One acre, sown with barley, and manured with oil-compost	0	18	0	5	5	0
One acre adjoining, sown with barley, and manured with rotten dung, twelve loads, worth	3	0	0	4	3	2
Difference				1	1	2

* By James Stovin, Esq. of Doncaster.

The compost barley was bolder and better corn than the other.

In the year 1770, the dunged acre produced of rye, three quarters. The compost acre, of ditto, two quarters six bushels.

In the year 1771, the same lands were sown with oats, and the produce was greatly in favour of the dunged acre This last experiment, being contrary to the idea of good husbandry, was made with a view to determine the *absolute* strength of the compost. All top-drefsings are exhausted in the year. The oil-compost seems to retain its vigour longer. It will here be proper to observe, that these experimental lands were in a common field, which had been many years under the plough.

X.

On the Oil-Compost.*

In the spring 1770, I prepared a piece of ground for onions. It was laid out into six beds of equal size, and all sown at the same time.

---

* By Richard Townley, Esq. of Belfield.

Over two of them, the oil-compost was scattered in a very moderate quantity. Over other two, pigeon-dung. And over the remaining two, some of my weed-compost, which I esteem one of the best manures, for most vegetables, that can be made*.

The onions came up very well in all the beds; but, in about six weeks, those that were fed with the oil-compost plainly distinguished the advantage they had over the rest, by their luxuriancy and colour; and, at the end of the summer, perfected the finest crop that I had ever seen, being greatly superior to the others both in quantity and size.

The same spring I made an experiment upon four rows of cabbages, set at the distance of four feet every way. Two were manured with the oil-compost, and two with my own. All the plants were unluckily damaged, just before they began to form, by some turkies getting into the field, and plucking off the greatest part of the leaves. However, they so far recovered as to weigh, in the

* This compost is formed of vegetable substances reduced into putrefaction.

September following, from 22 to 28 lb. a-piece. The rows proved so equal in goodneſs, that I could not determine which had the advantage.

The same year, one part of a field of wheat exposed to the north-east winds, which that spring continued to blow for a month or five weeks, appeared very poor and languid at the time of tillering. Over it I ordered some of the oil-compost to be sown with the hand, which not only recovered, but also pushed forwards the wheat plants in that part of the field, so as to make them little inferior, if any, to the rest.

The same spring I made a comparative experiment upon four contiguous lands of oats, between the oil-compost and my own weed-compost. The latter had manifestly the advantage, though the other produced a very fine and large crop. I also tried the oil-compost upon carrots, and it answered exceedingly well. I did the same this year, (1771) both upon them and my onions; and have the finest crops of those vegetables I ever saw any where upon the same compaſs of ground.

XI.

To make a rich Compost of Pond-mud, &c.*

We may naturally suppose that the mud of ponds, in general, is of a rich nature, when we consider the materials of which it is composed. First, Ponds, from the lownefs of their situation, receive the drainage, and consequently the riches of the adjacent lands around them. Secondly, A supply of various matter is constantly brought by the wind, and particularly the leaves of trees during the winter season. Lastly, Cattle afford the greatest supply by their dung and urine, as they frequent ponds at most seasons, but chiefly in warm weather.

Let the pond be cleaned out any time during the summer; if the mud is soft and slimy when taken out, it will be proper to let it lie a short time near the pond bank to harden: Then mark out a staddle, in proportion to the quantity of mud taken out, which if not very considerable, the first course, or foundation of the intended heap, may be made of common mould, taken from any mound,

* By Mr. William Speechly.

hillock, &c. where it is most convenient, which should be laid at least one foot thick; upon this lay a course of dung, fresh from the stable, fourteen or fifteen inches in thicknefs: next put a layer of pond-mud, nine or ten inches thick, upon which lay a course of lime, fresh from the kiln, five or six inches thick; and so alternately a layer of dung and lime between every two layers of pond-mud, till the whole is finished. In this place it should be remarked, that it is absolutely necefsary to separate the layers of lime and dung by a layer of pond-mud.

In places where they can be got, the offal of animals, soot, saw-dust, sweepings of streets, or in short any vegetable or animal substance that is reducible, will be exceedingly proper to add to the compost. The whole may be covered with a coat of common mould. The dung and lime will occasion a gentle ferment throughout the whole mafs, the bottom layer excepted.

After the heap has lain three or four months, it should be turned over with the spade, and by the next spring it will be ready to lay upon tillage land; but if it is intended to be used as a top-drefsing, it should then continue in the heap till the following winter, by which time it will become a fine rich compost, exceedingly proper for that purpose.—In the latter instance, a good crop of potatoes may be got upon the heap, and it will save expense and trouble in weeding.

The quantity of mould in the bottom layer, and also in the covering, may be varied at pleasure.

XII.

*On protecting Wall Fruit**.

Hearing that covering fruit-trees growing against a wall, would protect them from the effects of frost, at the time when the blofsoms make their appearance, I determined on making the trial upon a well-spread Apricot-tree, which grew upon a south wall; and in order that the experiment should prove conclusive, I covered one half of the tree with a net, leaving the other half exposed to the weather. The consequence was, the covered branches produced fruit abundantly, while the exposed branches did not

* By William Duffin, Esq.

bear a single apricot. The net was put on when the blofsoms made their first appearance, and kept on till the fruit was fairly set. I observed on this experiment, that the net attracted the moisture of the atmosphere, which occasioned the threads of the meshes to be constantly covered with ice, when the evenings and mornings were disposed to be frosty.

XIII.

*How to improve the Turf of poor Pasture Lands**.

It is well known that the turf on poor land, constantly gets worse a few years after having been laid down for pasture. The cause is obvious. There are a few spirey grafses, natural to most poor lands, and these are called *natural grafses.* The seeds of clover, and other kinds of grafses introduced, are generally termed *artificial.* The roots of these are not very durable on poor land, and as cattle are greedy of these grafses, they constantly crop them; and prevent their going into seed, whereby the land is deprived of fresh supplies of young plants; whereas the natural grafses, in general, being much in-

* By Mr. William Speechly.

ferior to the former in quality, are refused by cattle, and the land, consequently, soon becomes plentifully stocked with them.

The general mode of practice to improve land when the turf gets thin and bad, is to bring it under a course of ploughing. But when that is not convenient, or when the occupier of such lands is not inclined to introduce the plough, they may be greatly improved by having fresh seed sown upon them. The best season for doing it is in the beginning of April. Let the ground first be well worked over with a heavy bush harrow, this will brush up and raise the soil, and the better prepare it for the seed to strike. A drefsing of compost-earth should then be given, and the seed sown thereon; after which, let the ground be lightly brushed over, and well rolled. If the season prove moist and kind, the seed will thrive to admiration, and wonderfully improve both the turf and verdure.

Land that has been greatly cut up by carriages, or much trode up by cattle, is also capable of being thus improved, without the drefsing of compost-earth.

In paddocks where the land has been cut up even to an extreme degree, by rude and wanton horses, I have seen a new and verdant turf arise, even to amazement, in a few weeks after sowing the seeds. It will be necefsary to observe, that cattle should be prevented from coming upon the land till the turf get well set.

It were much to be wished that farmers would at all times pay the utmost attention to the saving of hay-seeds, but particularly at the season of making the hay-ricks; a consideration of great importance. Large quantities of seed may be saved, by having a cloth constantly kept between the rick and the waggon, at the time of unloading the hay. The seeds, that shell out at that season are certainly in the greatest perfection, being perfectly ripe, and totally uninjured by the heating of the hay.

XIV.

How to renovate an old Mulberry-tree.*

It often happens that old Mulberry-trees become bad bearers, or cast their fruit before

---

* By Mr. William Speechly.

it comes to maturity. In either of these cases, let a trench be cut about two feet deep round the tree, and about four feet from the bole. Let this trench be filled with fresh mould, enriched with cow-dung; and as the large roots may be raised without inconvenience, let the compost be put under them, so as to make the bed, over which the tree stands, as rich as poſsible. At the same time, let the old wood be cut from the head of the tree, in order that the young wood may have space to grow in. These operations being judiciously conducted, you will, in a few years, have an old tree converted into a young one. Let it also be observed, that, if you expect plenty of fruit, you must never permit the ground to be cropped near the tree, for by the spade, the feeding fibres of the roots will be cut off at the time when the fruit requires the utmost nourishment.

XV.

A general Idea of the Oil-Compost.*

This compost was originally formed upon the supposition that oily particles constitute the chief nourishment of vegetables. The use

* By A. Hunter, M. D.

of rape-dust, and other oily and saponaceous manures, place this doctrine in a favourable light. It now remains that we determine the merit of the compost by accurate experiments.

The oil-compost may be used two ways: It may either be sown upon the surface with the hand, or worked into the soil by the plough or spade. For corn and horizontal feeders, the first method is most proper. The latter is best for cabbages, hops, beans, carrots, and all tap-rooted plants. When distributed upon the surface, it is soon meliorated by the action of the air, rains, and dews. When worked into the soil, it is deprived of those necefsary influences. Here lies a material distinction which leads to its right use and application.

Previous to the planting of any deep-rooting vegetable, the compost should be worked into the soil by the plough or spade. Its particles, when undivided, are too hot for the tender shoots.

Some injudicious inquirers have placed a handful of the compost close to the roots of a cabbage plant, flattering themselves that they were then conducting an *experimentum crucis.*

Death, or a feeble vegetation, ensued. Hence arose an argument against the *nutritive* power of the compost. Lime, the ashes of burnt vegetables, stale urine, goose and pig-dung, when improperly applied, are also poisons. It requires some judgment to plan, as well as to reason upon an experiment.

Experiments correctly made, constitute the basis on which agriculture ſhould be raised; but those experiments should rather be the effect of reason than of chance. To plan an experiment well, to trace it minutely through its progreſs, and to draw a just conclusion, requires a perfect knowledge of the history of nature and of art. From a defect in these particulars, we often become hasty in our praise, as well as indiscreet in our censure.

From a variety of experiments, I find that the compost should be prepared some months before it is used: It should also be frequently turned and exposed to the influence of the atmosphere. This last operation is absolutely neceſsary when the compost is intended to be worked into the soil with the spade. By that means the acrimony of the salt will be abated, and the plant, instead of being burnt up, will be encouraged to spread its roots in quest of nourishment.

It will here be necefsary to observe, that the oil-compost was originally intended as a substitute for rape-dust, and other expensive top-drefsings. In all respects it must be considered as inferior to rotten dung.

XVI.

*A profitable Method of sowing Wheat on Land too strong for Turnips**.

In the year 1768, I had a field about six acres, which, in the common course of husbandry, should have been summer-fallowed, in order to prepare it for sowing wheat at the latter end of the year. The soil being a loose crumbling clay, I sowed it with rape, about a fortnight before midsummer, instead of fallowing.

On the 25th of September, it was stocked with sheep, and eat close to the ground; and about a month after that, it was sown with

---

* By Mr. E. Cleaver, of Nunnington.

wheat upon one ploughing. The winter being open, great part of the rape, which was ploughed in, revived in the spring. This, I feared, would endanger the crop. In that situation things remained till about the 20th of April, at which time I thought the rape was in full sap. I therefore judged this the most favourable season for destroying it. For that purpose I turned in as many ewes and lambs as eat both rape and wheat down in a week; and this had the desired effect, by utterly destroying the rape. The field was then left to take its chance. As no weeds appeared, there was no expense upon that article. The produce was thirty-six bushels per acre, Malton measure, which is five per cent. above Winchester.

I must here observe, that the year 1769 was remarkable for the largeneſs of its produce on lands in general; and, though I am very inclinable to prefer this method of cultivating wheat, yet, upon an average, I should think that twenty-eight bushels per acre is as much as we can reasonably expect, though the land be in good condition.

I say I am inclined to prefer this method, because turnips would be of little value to eat off on that kind of land, and at that early season of the year, when they are not sufficiently swelled. Were we, in order to remove that difficulty, to sow them earlier than the usual season, they would probably be either thick-necked or run to seed.

It will hardly be necefsary to observe, that the corn produced upon this field was remarkable for the goodnefs of its quality.

THE PRODUCE:

36 bushels of wheat at 5s.	£9	0	0
Rape eatage at Michaelmas	1	10	0
Ditto in April	0	5	0
Per acre	10	15	0

XVII.

On Siberian Spring Wheat *.

On the 2d of April, 1771, I drilled two pecks of Siberian spring-wheat on one-third of an acre, in rows one foot asunder. Previous

* By Sir Digby Legard, Bart. of Ganton.

to sowing, the wheat was limed in the usual manner. The land a rich loam, which had borne a crop of turnips fed off with sheep. The turnips were fine ones, and the land, which lets at sixteen shillings per acre, was in such good order, that I judged one ploughing a sufficient preparation for the wheat crop. The season was at first unkindly, and the corn came up very thin, with many weeds amongst it. It was hand-hoed, and soon after flourished and tillered amazingly. Though it appeared fine about the time of maturity, there were, notwithſtanding, many weeds amongst it, and it did not seem quite a full crop. In the beginning of October the corn was cut, and on the 19th of the same month was thrashed. The produce, 12 bushels, 2 pecks, viz. 25 for 1. This appears a considerable produce on the seed sown. The grain was well ripened, and in appearance (for I have not yet sent it to the mill) not inferior to any of the common wheats sown at the usual time. This kind of wheat seems a real acquisition to husbandry; and yet some common white wheat, sown at the same time, had the appearance, whilst growing, of producing somewhat a larger crop, only it did not ripen so kindly, and was also later in ripening. But if this Siberian wheat was superior to the common spring-wheat, it was certainly greatly inferior to some wheat of Switzerland sent me by the Society of Arts, and sown on land contiguous to the above, and at the same time. This last was as fine a crop as one could look on, ripened a fortnight sooner than any of my spring-wheats, and was as early as any of the autumnal sorts.

XVIII.

On the Method of raising Seedling Potatoes.*

Take a bunch of the apples of a white potatoe. Hang it up in a dry place during the winter, and in February separate the seeds from the pulp, by washing the apples in water, and prefsing them with the fingers. Then dry the seeds upon paper. In the month of April, sow these seeds, in drills, in a bed of earth well dug, and manured with rotten dung. When the plants are about an inch high, draw a little earth up to them with a hoe, in order to lengthen their main roots. When they are about three inches high, dig them up with a spade, and separate them carefully from each other, in order for planting out in the following manner.

* By A. Hunter, M. D.

Prepare a piece of fresh ground by trenching it well. Dig up the seedling plants as before directed, and plant them out in the ground, thus prepared, in such a manner, that there shall be sixteen inches between each plant.—As they advance in growth, let them receive one or two earthings up, in order to lengthen the main root, and encourage the shoots under ground.

By this management the potatoes will, in the course of one season, arrive at a considerable size, and the haulm will be as vigorous as if sets had been planted. But what proves the luxuriancy, in the most convincing manner, is, that flowers and apples are sometimes produced.

In Lancashire, where the gardeners raise potatoes from seed, they are always two years in bringing them to full size. By the above method of transplanting, with wide distances, many of the potatoes will attain their full size in one season.

It is observable, that these seedlings produce potatoes of many different kinds; and sometimes new sorts are procured. We do not find any difference whether the apple comes from a round or a kidney kind. It is not so when we use the set, which invariably produces the same kind.

Apples taken from a red potatoe that has flowered in the neighbourhood of white ones, will sometimes produce a kind internally marbled red and white, as I found from an experiment made in the year 1773—and I presume, for the same reason, that apples taken from a white potatoe that has flowered in the neighbourhood of red ones, will produce something of the same kind. This proves to a demonstration, that the male farina is received into the female organ, without which there could not pofsibly be an impregnation of the seeds lodged in the ovarium. The idea of animal generation, as given us by Lewenhoek, is similar to this, and is in a great measure, confirmed by it. In both cases, however, there remains a difficulty in explaining how those mongrel productions are formed, that partake of the nature of the male and female parents. But this disquisition is foreign to the present purpose, and more properly belongs to the Efsay on the Sexes of Plants.

Potatoes, when propagated from sets, after a number of years, are found to decrease in bearing; for which reason they should be brought back every fourteen years to their original.

From a want of attention to this circum stance, I have known potatoes so run out, that they hardly returned treble seed. The farmer complains that his land is tired of them; but the true cause is the age of the sets.

The increase of potatoes raised from seed is astonishing. They continue in vigour for about fourteen years; after which, the produce gradually declines.

XIX.

On the Alternate Husbandry.

The alternate husbandry seeming well calculated for lands in this part of the world, I was induced to make trial of it in a field of forty acres Irish †; the soil a good kind of loam, but so full of large stones as continually

---

* By Lewis Irvin, Esq. of Tanrigoe, in the kingdom of Ireland.

† Ten acres Irish are equal to sixteen English.

to interrupt the plough. Add to this, its being sadly mangled with old rotten ditches, the foundations of which were mostly composed of these large stones. To bring this field into proper culture, the alternate husbandry was admirably calculated, as it gave me an opportunity of rolling off the stones and rubbish upon the lea, where they remained till I had leisure to remove them. These stones I got drawn off, and built into a wall five feet high, at the rate of three shillings the rod (21 feet); and which I may have capped and pointed with lime-mortar for half-a crown more. By this method I get a fence that will last for ever. Agreeable to this plan I propose to divide my whole farm into inclosures of ten acres Irish. My grounds being much exposed to the sea, I prefer that size on account of the shelter.

It was in the spring of the year 1770 that I began my experiment upon the alternate husbandry; and, from what I have observed, in the first year, I am determined to continue that system of farming. It diminishes the expense of manure, and secures a clean fallow; two objects of the utmost importance.

I have above observed, that my experimental field was forty acres Irish. The whole was disposed in lands about four yeards broad. Somewhat lefs than one half of the field was sown with 220 stones of oats, which is about half the seed usually put into the ground here. The corn ripened kindly, and I reaped 3200 stones; a greater crop than my neighbours had from double seed. I could not help being greatly satisfied with my succefs, as I was much ridiculed by the name of the Striped-Lutestring Farmer. The oat-lands are now (Jan. 1771) ploughed and split, and will be fallowed for wheat in September. The lea-lands I shall sow in the spring with oats; and make no doubt of obtaining a crop superior to the last year.

The period of time employed in this experiment, cannot justify me in making absolute conclusions. It is, however, sufficient to encourage me to prosecute the plan as laid down in the seventh efsay of this volume.

XX.

The Dimensions of an Earthen Fence, as made in Northumberland.*

The fence must be five feet in breadth at the bottom. One foot to be allowed for to plant the quicks on the side next the ditch, and one foot on the other side for the breast of the dike; so that the whole breadth will contain seven feet. The fence must be made four feet two inches high. The ditch four feet wide at the top, and one yard in the slope, and must be one foot three inches broad at the bottom. The top of the fence must be one foot three inches in breadth. The fence, at the top, must be covered with a sod, the green part uppermost. Four quicks in every foot. These must be put in horizontally; so that, when the stem shoots upward, it forms a right angle with the old stock. And this method is found practically better than when the set is put down in a perpendicular direction. By this mode of fencing, no posts or rails are required. The price in Northumberland is sixpence for each rood of seven yards.

---

* By Thomas Riddell, Esq. Felton Park, Northumberland.

XXI.

A Method of preparing a rich Compost.*

Take a sufficient quantity of saw-dust.—incorporate with it the blood and offal of a slaughter-house, putting a layer of one, and a layer of the other, till the whole becomes a moist and fœtid composition. Two loads of this compost, mixed with three loads of of earth, will be sufficient for an acre of wheat, or spring-corn. Being a kind of top-drefsing, it should be put on at the time of sowing, and harrowed in with the grain.

It will be necefsary to remark, that this species of manure seems best adapted for lands of an open texture. Tough clays require lime and plenty of dung to break the cohesion of their parts. Farmers should attend to this distinction.

This present year I have a field of wheat manured in this manner, and have the pleasure to say, that it is extremely clean, and has all the appearance of turning out an excellent crop. As this kind of compost lies in

* By A. Hunter, M. D.

a small compafs, it seems well adapted for the use of such farmers as are obliged to bring their manures from a distance. It is besides extremely rich, and will probably continue in the land much longer than fold-yard or stable-dung. I apprehend that it is capable of restoring worn-out land to its original freshnefs; and I am induced to be of that opinion from the appearance of the above wheat crop, which is now growing upon land much impoverished by bad management.

All animal substances being of the same nature, it is probable that the refuse whale-fat, after the oil is boiled out, will make a compost of equal goodnefs with the above. I have at present a dunghill made of that offal and horse-dung, hot from the stable. I prefer the fresh dung on account of its reducing the blubber more speedily into a putrid state.—The preparers of train-oil constantly throw this offal into the sea; but I apprehend that saving it for the purposes of vegetation will be of national advantage. Being an animal substance, there is no doubt of its containing all the principles of other animal bodies; consequently it must be an object worthy of the attention of such gentlemen as live in a neighbourhood where train-oil is prepared*. We cannot recommend in too forcible a manner, a proper attention to every substance that is capable of being brought into a state of putrefaction. Notwithstanding what the ingenious Mr. Tull and others have wrote, it is certain that manures, properly managed, are the life and soul of husbandry. Few things, however, in the extensive field of rural economy, are so imperfectly understood. Until the doctrine of manures is clearly and distinctly, laid down, agriculture will remain a vague and uncertain study.

XXII.

A comparative View of the three different Methods of sowing Barley†.

It is undecided amongst farmers which is the best method of sowing grain. To determine the debate, as far as one experiment can be said to determine any thing, I made the following trial.

In a field of twenty acres, which the year before had borne a crop of turnips, I selected

* Proposed about thirty years ago. It is now (1801) universally attended to.

† By the Rev. Sir W. Anderson, Bart. of Kilwick.

three contiguous lands, each of which measured five roods. The soil, a loamy clay of five inches upon a hard bed of chalky limestone. I sowed N° 1 with the four-socked drill-plough, in rows eight inches asunder.—N° 2, under furrow. N° 3, above furrow. The drilled land was finished in two hours, and took three bushels and a half of seed. The other lands were finished in the usual time, and had each the same quantity of seed as the drilled part. The saving in seed is not an object of so much importance in the drill husbandry as is commonly imagined. On the contrary, I am of opinion that the failure of drilled crops often proceeds from too great an attention to this economical part of the system.

For about a fortnight after sowing, the season was rather dry. N° 1 appeared first. N° 2, next. N° 3, last. During the time of growing, the lands had the appearance of being equally good, and, as the season was a favourable one for barley, the ears ripened kindly.

On the 4th of October the corn upon the three experimental lands was cut.

THE PRODUCE:

N° 1.	——	60 stooks.
2.	——	67 stooks.
3.	——	65 stooks.

Not having the opportunity of thrashing out the whole crops at this season of the year, I ordered one stook of each land to be housed, and carefully thrashed.

MEASURE:

N° 1.	——	3 pecks.
2.	——	3½ pecks.
3.	——	3¼ pecks.

To be satisfied of the relative goodneſs of each, I weighed the products.

WEIGHT:

N° 1.	——	2 st. 12 lb.
2.	——	3 st. 3½ lb.
3.	——	2 st. 9½ lb.

From this experiment we are led to make the following reflections.

1. That sowing barley under furrow, gives the greatest produce.

2. That sowing above furrow is next.

3. That drill-sowing in equi-distant rows of eight inches, is inferior, in quantity, to both.

4. That the drilled barley is considerably the heaviest.

5. That the under-furrow is next.

6. That the above furrow is lightest.

I ought here to observe, that N° 2 had two ploughings, but that N° 1 and N° 3 were sown upon a single ploughing. It will also be proper to remark that, for want of experience in the person who conducted the drill-plough, the bouts were not so regular as they ought to have been, which occasioned, in many places, a considerable lofs of land.—From these circumstances I am induced to think the experiment not so perfectly decisive as I could wish. In a short time I hope to be able to measure and weigh the whole produce, by which means the above comparative trial will be rendered more conclusive.

XXIII.

On the Oil-Compost *.

On the 1st of October 1771, I sowed two acres of a light channelly soil with wheat, and harrowed in the compost with the grain. Being at a considerable distance from a large town, we find it very difficult and expensive to procure rotten dung in sufficient quantity for our tillage lands, for which reason we have recourse to hand-drefsings both for our winter and spring corn. Rape-dust and soot are princicipally used, but the present price of both these articles is a heavy tax upon the farmer. To obviate that inconvenience, I resolved to make trial of the oil-compost; and from what I have observed in this one experiment, I am encouraged to make a more extensive use of it next year. Being well acquainted with the nature and efficacy of soot, I am satisfied that the above two acres produced as good a crop of wheat as if they had been drefsed with that excellent manure.

* By Mr. J. Broadbent, of Barwick in Elmet, near Leeds.

XXIV.

*On the Juice of Carrots, &c**.

For many years carrots were appropriated to culinary uses only. They are now found to be an excellent food for horses and hogs †. I have often thought that their expreſsed juice might be converted by a cheap proceſs into ale, spirit, and vinegar. Some experiments that I made in the year 1772 ‡, though they did not perfectly succeed, confirm me in that opinion.

I beg leave to recommend to the philosophical farmer an examination of the carrot juice. It is a subject worthy of his attention.

---

* By A. Hunter, M. D.

† *Vide* the ingenious Mr. Young's Eſſay on the management of hogs.

‡ The vinous fermentation went on agreeably for about six hours, after which it suddenly ceased. This experiment was several times repeated, and with the same appearances. Probably a portion of brown sugar, or molaſſes, may be of use in keeping up the fermentation; though, from the sweet taste of the juice, one would not suspect an addition of that kind neceſsary. The pulp of the carrot, when mixed with bean meal, makes an excellent food for hogs, and is preferable to grains for milk cows.

One acre of good carrots (eighteen tons) will produce forty hogsheads of a saccharine juice. Dr. Marggraf was not able to obtain crystallized sugar from carrots, though he got it from skirrets and beets. An examination of these juices, with a view to obtain wine, spirit, and vinegar, may be worthy of notice. The procefs for sugar is too expensive for practical use.

As an inducement to others, I shall here subjoin Dr. Marggraf's experiments.

" The plants," says this ingenious inquirer, " which I chymically examined in order to extract sugar from their roots, and which yielded a considerable quantity, are very common in most countries, and require neither a fine soil nor afsiduous culture; such, for instance, are,

1. White Beets.
2. Skirrets.
3. Red Beets.

" The roots of these three plants yielded a large quantity of pure sugar. You may know the roots of the plants which contain sugar by these characteristics: When you have cut the roots in pieces, and wiped them very clean, they have a very agreeable taste; and if you examine the pieces by a microscope, you will perceive whitish crystalline particles, which are a true sugar.

" As sugar is a salt which diſsolves even in brandy, I imagined that the sugar might be separated from the parts of plants by means of the best and strongest brandy I could get. Previously to determine the quantity of sugar diſsolvable this way, I put into a glaſs an ounce of the finest and best sugar, well pulverized, together with four ounces of the strongest brandy; the whole being well digested, I boiled them together, and the sugar was soon perfectly diſsolved. Whilst this solution was yet warm, I strained it through a linen cloth into another glaſs; I corked it close, and after it had stood eight days, I had the pleasure of seeing the sugar form itself anew into very fine crystals. To succeed in this experiment, the sugar and glaſs must be quite dry, and the brandy well rectified.

" Having prepared the way by this experiment, I took the roots of white beets, and, having cut them into small slices, I laid them by the fire to dry, taking care not to burn them; I then reduced them to a coarse powder, and laid it to dry a second time, because it is very apt to contract moisture: whilst this coarse powder was yet warm, I put eight ounces of it into a glafs vefsel, and poured upon it sixteen ounces of brandy, so strong that it fired gunpowder. The vefsel was above half full, and having corked it close, I set it in a sand-heat till the brandy began to boil; stirring it from time to time, that the powder might not settle to the bottom.

" As soon as the brandy began to boil, I took the vefsel off the fire, and poured the mixture as quickly as pofsible into a linen bag, and prefsed it well to squeeze out all the liquor; I then pafsed this liquor through a linen cloth whilst it was yet warm, and put it into a glafs vefsel well corked, and set it in a warm place. The liquor was at first turbid, but after some weeks a crystalline sediment appeared, which had all the characters of an impure sugar, and was full of very hard crystals. To purify them yet more, I difsolved them a second time in brandy, and proceeded in the same manner as I had done with the real sugar.

" By this method, which was the first that I fell upon, I obtained from the three roots above-mentioned the following quantities of sugar:

" 1. From half a pound of white beets, half an ounce of pure sugar.

" 2. From half a pound of skirrets, an ounce and an half of pure sugar.

" 3. From half a pound of red beets, one ounce of pure sugar.

" It is evident, from these experiments, that lime-water is not at all necefsary to dry and thicken the sugar, as some pretend, since the sugar crystallizes without it.

" Being thus afsured that there was real sugar in plants, I endeavoured to find out a lefs expensive manner of extracting it; and the best way seemed to me, first to prefs out the juice of the plants, then to purify this juice, and to prepare it for crystallizing by evaporation; and lastly to purify the crystals that proceeded from it.

"I took a certain quantity of skirrets; I cut the roots, whilst fresh, into small pieces, and pounded them as small as poſsible in an iron mortar; I then put them into a linen bag, and preſsed out the juice in a preſs prepared for the purpose: after this I poured water upon the roots remaining in the bag, and preſsed them a second time. I then put the liquor all together into a very clean veſsel, and let it stand to settle in a cool place for forty-eight hours; in which time it became clear, and a mealy substance settled to the bottom; I then poured off the liquor gently, and paſsed it through a linen cloth into another veſsel.

"The first clarification being thus made, I put some whites of eggs to the juice, and boiled it in a braſs pan, scumming it continually till no further impurities appeared on the surface; I then paſsed it through a linen cloth, and the liquor was as transparent as the clearest wine. I boiled it again in a leſs pan till it was considerably decreased, and so again and again, in yet leſs veſsels, till there remained only a pretty thick syrup, which I put into a very clean glafs vefsel, and set it in a warm place. I let it stand above six months, and then found the sugar sticking to the sides of the glafs in the form of little crystals.

"To purify these crystals, I put the vefsel into warm water, and when the heat had penetrated the glafs, so as to render the mixture fluid, I poured both the liquor and crystals into an earthen vefsel, broad at top and narrow at bottom, and the bottom perforated with several holes; this vefsel I put into another, and covered both up, and set them in a temperate place: by these means the syrup gradually dropt into the lower vefsel, and the crystals were left in the upper one. This crude sugar I then put into blotting paper, folded different ways, and prefsed it lightly in a prefs; this dried it, and rendered it more pure, the paper imbibing a good deal of the tenacious viscid syrup, which yet stuck to the sugar.

"The sugar, thus cleaned of the greatest part of its impurities, I difsolved again in water, pafsed it through a clean linen cloth, and boiled it to the consistence of a thick syrup, then put a little lime-water to it, and boiled it gently till it became ropy; I then took it off the fire, and stirred it about till it cooled and thickened a little; after which I poured it into a well-burnt earthen veſsel in the form of a cone, closed at the small end with a wooden stopper, which veſsel I put into others that were deeper, and set them in a temperate place. In a few days the sugar became tolerably hard and full of crystals; and when it had stood eight days, I took out the stopper, and set the veſsels in a warm place that the syrup might run off: this syrup is fit for the same uses as common treacle; and the sugar, after drying and purifying by means of the blotting paper as before, is equal to the best brown sugar of St. Thomas, commonly called Moscovad. By a similar proceſs, sugar may be extracted from red and white beets. The sugar of skirrets is of a better quality than that of red beets, but the sugar of white beets is best of all.

"I endeavoured to extract sugar from the stems and leaves of these plants, but could obtain from them only a sort of tartar: it is very remarkable that the roots of these plants should contain sugar, and that the stems and leaves should be entirely destitute of it.

" These experiments may be useful to farmers and other people of this country in low circumstances. Instead of buying sugar, which is very dear, they may obtain it from the plants at their own doors; they need not go through all the steps of the foregoing procefs; for them it may suffice to exprefs the juice, to strain and purify it a little, and then to boil it down to the consistence of a syrup, and so use it; it will certainly be more pure than the grofs treacle of the shops. Besides, from these experiments we learn, that those countries which produce the sugar-cane, are not the only ones which nature hath furnished with sugar.

" I made trials upon several other vegetables besides those I have mentioned; I could obtain no sugar from carrots; the juice they yielded was extremely sweet, but resembled honey rather than sugar; parsnips yielded a little sugar; two species of dogs-grafs yielded a very sweet juice, but not sugar; the juice of the Birch-tree yielded a sort of manna."

From these experiments it is abundantly evident, that many common roots of this country contain a large share of saccharine juice. They consequently are capable of being converted into wine, spirit, and vinegar. To determine this point, (in 1773) I took 24 bushels of carrots in the month of October. After being washed, topped, and tailed, I put them into a large brewing copper with four gallons of water, and covering them up with cloths, to hasten the maceration, I ordered a fire to be kindled underneath, which in a short time reduced the whole into a tender pulp. They were then put into a common screw-prefs, and the juice taken from them, which, together with the liquor left in the copper, was run through a flannel bag. The juice was then returned into the copper, and, as it was my design to make it into ale, I put to it a proportionable quantity of hops. The liquor was then boiled about an hour, when it acquired both the taste and colour of wort. It was next put into a cooler, and afterwards into the working vefsel, where the yeast was added to it. It worked kindly, and in all respects was treated as ale. I allowed it to remain in the cask about four months, when I broached it, but found it of a thick and muddy appearance. I attempted to fine it, but in vain. The taste was by no means displeasing, as it much resembled malt liquor. My first intention being frustrated, I threw it into the still, being about forty gallons in measure, and by two distillations obtained four gallons of a clean proof-spirit. It had, however, contracted a flavour from the hop, which should be left out when the intention is to reduce the liquor into spirit. From a grofs calculation, I am induced to think that a good acre of carrots, manufactured in this manner, will leave a profit of forty pounds after deducting the landlord's rent, cultivation, distillation, and other incidental expenses. In this calculation, I presume that the spirit is worth six shillings per gallon, and not excised. An acre of barley will by no means produce so much spirit. A rich sandy loam is the best land for carrots, which, after the crop is removed, will be in high cultivation for corn. The succefs of my trial, will, I flatter myself, be the means of inducing others to repeat the experiment, with a view to determine how far the growth of carrots for the use of the distiller may be considered in the light of a national advantage.

XXV.

On a Method of raising Potatoes in Winter.*

Make a compost of earth, sand, and coal-ashes. With this mixture fill a tub about sixteen inches deep. Plant this artificial soil with some sets of the early round potatoe, and place the tub in a stable opposite to a window, taking care to water the earth now and then. In all seasons the sets will sprout, and give a tolerable increase of potatoes. Last November I planted some sets in the above manner; and, in the February following, I took up a considerable number of young potatoes, clean skinned and well flavoured.

XXVI.

On sowing Turnips for late feeding†.

The advantages of having Turnips good till the spring-feed is ready, are so obvious and so great, that it is matter of wonder that so few farmers do follow the custom in Norfolk,

* By Mr. Seth Agar, York.

† By a Suffolk Farmer.

which is to continue sowing turnips to the latter end of August, by which means their late crops remain good in the field till the latter end of April, and often till the middle of May. The farmer will gain the same advantage by cultivating the Ruta Baga, or Swedish Turnip, which is daily coming into use by such farmers as have spirit to leave the beaten track of their forefathers.

XXVII.

On feeding Sheep, and a substitute for folding.*

An eminent farmer in Bedfordshire has found that nothing is so beneficial in feeding sheep on turnips, by way of addition, as pease. A small quantity, as two or three bushels a day, to one hundred and fifty wethers, has a considerable effect, and the benefit to the land may be seen to an inch in the succeeding crop of barley. As to folding, farmers begin to be divided in their opinions. An excellent farmer in Norfolk, who rents a farm of 1800 acres, never folds, and is well persuaded that it is not at all necefsary. Another farmer of eminence, in the same county, who never

* By A. Hunter, M. D.

folds, informs me that his lays when he breaks them up for corn, pay him amply for leaving the sheep at night where they feed by day. The practice begins to decline in the neighbourhood of Holkham, but there certainly are some tillage-farms that cannot be advantageously managed without folding.

The trouble and expense of keeping a flock of sheep for the purpose of folding, may probably be avoided by forming large ponds, so constructed as to receive and hold water. Into these ponds, let drains from the stables, cow-houses, ox-stalls, piggeries, and wash-house, be directed; and in order to enrich the water, let all kinds of vegetable and animal substances be thrown in, particularly the contents of the necefsaries and slaughter-house. It is presumed that this putrid water, when put upon the land by means of water-carts, will prove as beneficial as a flock of sheep kept for the exprefs purpose of folding. A pond of sixty feet diameter, by six feet deep, will contain upwards of 700 hogsheads of water. It is presumed that a pond of this nature and size, when properly supplied with water and putrescent bodies, may be equal to a fold of —— sheep.

XXVIII.

A comparative View of two crops of Barley, the one drilled, and the other sown broadcast.*

The experiment was made to ascertain the the produce of drilled barley, compared with broadcast. The seed was sown on the same field, and at the same time, and there was no apparent difference in the soil. The drills were eighteen inches wide, and the grain was dropped by hand; the expense of which was three shillings and threepence per acre.

The seed drilled, was one bushel and three gallons per acre. The produce, fifty-six bushels and three gallons.

On the broadcast part, the seed sown was three bushels and five gallons per acre. The produce thirty-six bushels and five gallons.

Extra produce of the drilled crop, about twenty bushels per acre; besides near two bushels of seed sown.

---

* By Sir John Anstruther, Bart.

XXIX.

On Malt-Dust as a Manure.*

In April, 1784, I manured a piece of land with malt-combs, or the dust which falls through the wires, at the rate of four quarters per acre, and sowed it with barley and clover. The barley was very luxuriant, and produced near seven quarters per acre. The crop of clover was one of the finest I ever saw; and I have no doubt, but the effects of this manure will be evident in the wheat next year. From the succefs attending the use of this manure, the expense of which was only twelve shillings per acre, it appears to be much cheaper than rape-dust, or any other top-drefsing.

XXX.

On the number of grains contained in a bushel of wheat, and other seeds†.

As the drill-husbandry is gaining ground in many parts of this island, it seems to be a matter of utility, as well as curiosity, to be

---

* By Mr. J. Bedford.

† By A. Hunter, M. D.

informed of the number of grains contained in every bushel of corn sown. When wheat is drilled, or dibbled in, we suppose that every grain is covered, and consequently vegetates; but when sown broadcast, not much more than one half of it is safely covered by the harrows. The following calculations were made by a respectable Member of the Bath Agriculture Society, and which, if not of material use, will, at least, amuse the theoretical farmer.

An acre of land drilled at a foot distance, on ridges of eight feet three inches wide, contains in length 505,808 inches.

A bushel of wheat, weighing 62 pounds, contains 616,000 grains. Dropping one grain to an inch requires lefs than a bushel to an acre.

A bushel of barley, weighing 52 pounds, contains 515,000 grains.

A bushel of pig-pease, weighing 64 pounds, contains 107,000 pease.

A bushel of horse-beans, weighing 64 pounds, contains 35,000 beans.

As all kinds of grain vary in size, the number contained in a bushel will be increased or diminished; but the above are the average numbers, and there is reason to think that the emuneration is tolerably exact.

XXXI.

A Method of making excellent Butter from the Milk of Cows fed upon Turnips.*

Let the bowls, either lead or wood, be kept constantly clean, and well ſcalded with boiling water before uſing. When the milk is brought into the dairy, to every eight quarts mix one quart of boiling water; then put up the milk into the bowls to stand for cream. By keeping strictly to this method, I have constantly, during the winter, sweet and well-tasted butter from the milk of cows fed upon turnips. My cows are kept in the house at nights to hay, and are turned out in the day-time to turnips without waste.

---

* By C. Crowe, Eſq. of Kipling.

XXXII.

*A new and profitable Method of raising a Crop of Turnips in Drill**.

At this time, every one knows the consequence of turnips to the farmer in supporting his lean stock, and keeping up his fat in the winter season at an easy expense.

Though the growth of turnips is now become universal in the north of England, yet it does not appear that there is any general regularity observed in their cultivation. Particular soils hath hitherto determined the preference of turnip crops. This not falling to the lot of every one, induces me to publish such observations as I have from time to time made in a long series of years.

The first preparation for a turnip crop is to plough the land before the frosts set in. The benefit of this ploughing, critically observed, not only meliorates the soil, but also turns out, and exposes the eggs of that pernicious insect, the fly, to the severity of the winter. The next ploughing should be performed, crofs-

* By Mr. Benson, of Stainley, 1777.

ways, about Candlemas, or before the frosts are quite over, that a farther advantage may be taken over the remaining ova of the fly. The ridges must then be harrowed lengthways. After this, the discretional use of the plough, roller, and harrows is all that is necefsary to make a good preparation for sowing.

The last week in May, if the weather be moist and gloomy, if not, make use of mornings and evenings, begin by fetting the ridges at one about, and close them by a crooked harrow, which will lay them in the form of an arch. This being done, a furrow must be drawn down the middle of every ridge with a double mould-board plough, to receive the dung, which must be laid in heaps (about four to the load) down every tenth furrow. Six loads (twenty-four bushels to the load) will be sufficient for an acre. The dung must then be carried in scuttles from the heaps, and scattered, edge-ways, into the open furrows. Upon the manure thus disposed, the seed must be drilled by a hand-drill; after which the earth must be returned by a common harrow, passed crofs-ways over the lands.

About the fifth day, if the ground be moist, the young plants will make their appearance. As soon as they have got into rough leaf, they must be thinned by women and boys, with a small two-inch hoe. With this hoe, and the fingers, the plants should be left about two inches distant, which will be sufficient for the first hoeing. The second hoeing should be performed with a 6-inch hoe, before the leaves interfere, leaving the plants at about eight inches, which will prepare them for the third and last hoeing. This must also be done before the leaves interfere, allowing them sufficient room, according to the vigour of the plants, and the richnefs of the soil. In this last hoeing, particular care must be taken to cut up all the weeds, and to stir the ground near the ridges, where the plough cannot come.

The hoe-ploughings necefsary for completing the crop are three, and may be performed by a narrow plough of about seven inches, made in the common way.

The first is done by going round each ridge, and turning a furrow from the plants into the interval. When a number of these are finished, the field will appear in double ridges; one half of which will be stocked with plants, and the other naked. About a fortnight after this operation, the naked ridges must be split with the double mould-board plough, and the earth thrown to the plants. After this, it will be proper to send in a few women to pluck up such weeds as have escaped the former operations, with a view to prevent their perfecting their seed; otherwise the tillage intended for the benefit of the crop would produce the same effect upon the growth of the weeds, and increase them in an amazing degree. The labour of this is small, but the consequence is important.

EXPENSE PER ACRE.

First ploughing — —	£ 0	5	0
Second ditto — —	0	5	0
Harrowing — —	0	1	0
Third ploughing — —	0	4	0
Fourth ditto — —	0	4	0
Harrowing — —	0	0	6
Ploughing the ridges at one bout	0	1	6
Ploughing the furrows for seed	0	0	9
Six loads of dung and leading	1	1	0
Two women to spread the dung	0	1	0
A boy for drilling ——	0	0	6
Carried forward — —	2	4	3

Brought over — —	£2	4	3
Seed — —	0	0	6
Harrowing — —	0	0	6
Several hand-hoeings and weedings	0	3	6
Three several horse-hoeings	0	3	0
Rent — —	0	12	0
	3	3	9

It will not be improper to enumerate the advantages of this method of culture. The seed being placed upon the moist dung, will vegetate early in all circumstances of the weather; and the manure being well covered, will be secured from evaporation in the hottest seasons. The turnips being placed immediately over the manure, have a ready pafsage, by means of their tap-root, into a rich bed of nutriment, which will accelerate their growth, and increase their size. As the crop grows upon ridges, with a trench on each side, it is obvious that the turnips will remain dry in the wettest seasons; a circumstance of the utmost utility. To these advantages we may add the doubling of the soil, which I consider as an important article in all situations where the staple of the land happens to be thin.

XXXIII.

On the Quantity of Ashes to be obtained by Burn-baking.*

In August 1772 I pared and burnt one acre three roods of limestone land, and carefully collected the ashes into two heaps for a future experiment. Having so good an opportunity, I measured the ashes, and was much surprised at the quantity, being eighty cart loads, thirty bushels to the load.

I shall not here enter into the merits of burn-baking; but, from the above experiment, it is obvious that a complete drefsing may be obtained, in any country, upon very reasonable terms.

XXXIV.

On Spring Wheat†.

On the 6th of April, 1772, I sowed three roods of a turnip fallow with spring wheat, the soil about six inches deep, upon a lime-stone rock, and valued at ten shillings per acre.

---

* By A. St. Leger, Esq.

† By A. St. Leger, Esq.

I had the pleasure of seeing the crop cut down about a week sooner than the wheat sown in October, upon the same kind of land. Upon these three roods I had forty-two stooks, ten sheaves to the stook. When threshed, I had twenty-one bushels of clean corn; and should have had considerably more, had not the lands been much infested with sparrows. I shall not determine much upon this small experiment, as I propose to enlarge my trials very considerably next year. It will, however, be proper to observe, that my tenants were desirous of having part of the seed, but I chose to reserve it all for myself, well knowing that the common farmer should have nothing put into his hands but what has stood the test of accurate and judicious experiment.

XXXV.

*On sowing Carrot-Seed**.

Carrot-seed must be sown early; and as it remains a long time in the ground, the weeds frequently spoil the crop. The following method has been found effectually to prevent the above inconvenience.

---

* By A. Hunter, M. D.

Take any quantity of carrot-seed, and mix it with about five times the quantity of earth. Moisten the whole with water, and every second day turn the whole over. As soon as the seeds begin to swell and sprout, they may be sown along with the earth.

In this method, the carrot-seeds will vegetate before the weeds; and the farmer will be secure of a good crop, which may be easily and cheaply hoed.

XXXVI.

The Method of making Whale-Compost *.

I have a particular pleasure in describing and making public the best method of forming a compost from whales flesh, as recommended to me by Dr. Hunter. Having marked out the length and breadth of your intended dunghill, make the first layer of earth about a foot in thicknefs. Moor-earth, or such as is taken from ant-hills, is the best for this purpose. Over the earth lay one layer of long litter from the fold-yard, or stable, about twelve inches in thicknefs, then a layer of whale-flesh, and over

* By Mr. Charles Chaloner, 1772.

that another layer of dung. Repeat the operations till the heap be raised about six feet, then give it a thick covering of earth, and coat the heap with sods. In this manner, each layer of flesh will be placed between two layers of dung. In about a month, turn the whole in the usual manner, which will occasion a strong degree of heat and fermentation. When turned, coat with earth as before, with a view to confine the putrid steam which would otherwise escape. In a month or two the heap will be found considerably fallen, when it should have a second turning as before. The operation of turning must be repeated at proper intervals, till the whole becomes an uniform putrid mafs. The whale-flesh is of different degrees of firmnefs, some of it being almost liquid; and, in proportion to its firmnefs, the heap will become sooner or later fit for use. In general the compost should not be used until twelve months old; but that depends upon circumstances. Guard the heap from dogs, pigs, badgers, and vermin, as these animals are remarkably fond of whale-flesh.

This animal compost may, with great advantage, be applied to all purposes where good rotten dung is required. I have used it with great succefs for cabbages, and find it an excellent drefsing for meadow ground. According to the best computation, one hogshead of whale-refuse will make eight loads of dung, which, when we consider the great facility with which this basis of our dunghill may be carried, is a momentous concern to such farmers as lie remote from a large town.

When we take a view of the vast quantities of whale-refuse that used formerly to be thrown into the sea, to prevent the bad effects of its putrid steams, and now survey it as converted into the best of dunghills for enriching our fields and pastures, we are insensibly led to return thanks to the editor of these efsays, who has proved to a demonstration, that husbandry must be regulated and directed by the powers of reason and reflection.

XXXVII.

*On the Oil-Compost**.

In the spring of the year 1772, a piece of ground was prepared in my garden for onions; and after the seed was sown and raked in,

* By Richard Townley, Esq. of Belfield.

I had the usual quantity of oil-compost scattered over it. The ground measured forty-eight square yards, including four small paths for the convenience of weeding the crop. Great quantities were pulled up, during the growth of the crop, for the use of the family; great quantities were given to my labourers and poor neighbours, and even some thrown into my hog-yard, in order to thin the crop properly as it proceeded towards maturity.—On the 18th of September the crop was judged to be sufficiently grown, and ripe enough for keeping during the winter. The onions were then taken up; and after laying a few days to harden and dry in the sun, they were brought in and weighed, when the produce was found to be 304 lb. of a very large size. This produce is 6½ lb. to a square yard, or 30653 lb. to a statute acre, which at one penny per pond, the lowest price in our neighbourhood, amounts to 127l. 14s. 5d.—I must attribute this extraordinary produce to the oil-compost alone, as the ground upon which the onions were sown had been exhausted by a constant succefsion of different crops for forty years past, and was besides but of a middling quality.

XXXVIII.

A comparative View of Baron Van Haake's Compost, the Oil-Compost, and Soot mixed with Ashes.*

In the beginning of April, 1773, an acre of land was sown with forward oats. I pitched upon one land in the middle of the piece which I esteemed better than any of the rest, and upon this I scattered Baron Van Haake's compost, in the quantity directed in his instructions. On one side I manured a land with the oil-compost, but rather with a lefs quantity than directed; and on the other side I manured two lands with dry coal-ashes, sifted fine, and an equal quantity of soot. The lands upon which this experiment was made, were much worn out with a long succefsion of crops.

The lands which had the benefit of the ashes and soot produced an exceeding fine crop; the oil-compost produced a tolerable good one; but that land which had only the afsistance of the Baron's compost, produced a very poor one. It could not have been

* By Richard Townley, Esq. of Belfield.

worse, had it been left destitute of every afsistance. From this, and from some other experiments made by a worthy neighbour of mine, who was so kind as to furnish me with the Baron's compost, I have great reason to discredit the pompous accounts given of its extraordinary powers and qualities by its inventor, which appeared to savour so much of empiricism, that I should hardly have made the above trial, had not my ingenious neighbour intreated me to make the experiment. I should be glad to hear that the Baron's compost has succeeded better with others who have given it a fair trial; for was it pofsefsed of half the boasted virtues afcribed to it, it would prove a most valuable acquisition to the farmer and the public.

The same year in which these experiments were made, I tried the oil-compost upon some parts of my wheat crops, which discovered great weaknefs and poverty at the time of tillering, and with considerable succefs.

XXXIX.

*On Egyptian Wheat**.

In September, 1772, I received from a friend twelve grains of Egyptian wheat, which

* By Richard Townley, Esq. of Belfield.

I have reason to believe was the *Triticum ramosum et centumgranium* of Pliny, of the produce of which he gives such extraordinary accounts. After giving an account in what parts of Africa this remarkable species of wheat is produced, he says, " Et imprimis Ægypto." Six of these grains I gave to a neighbouring gentleman, the other six I put down in my own garden, at the depth of two inches within the soil, and nine inches distance from each other. The ground was kept hoed and clean from weeds, which was the only afsistance that was given to the plants. When the ears became heavy, I ordered the stems to be tied up to stakes, to prevent their breaking down with wind or rain. These six grains produced one hundred and two stems, with large branching ears, and the ears contained, upon an average, one hundred and twenty grains, or better; so that the produce of the six grains, at the medium of one hundred and twenty grains to each ear, makes 12,240, or 2040 from each grain. Most of the grains were plump and large, and the flour within was of a good colour. I cannot help exprefsing my fears, that this species of wheat, produced in the fertile soil and serene climate of Egypt, will be apt to degenerate in this island; though we have often found, by experience, that different kinds of grain, as well as plants, natives of countries far more favourable to vegetation than our own, have flourished very well amongst us; and to appearance have, in a series of years, afsimilated their natures to our soil and atmosphere. I propose to sow this kind of wheat at different seasons of the year; and if it can be kept up to its present standard, with early sowing, it will prove a great acquisition to agriculture. According to my trials, it stands our frosts as well as our common wheats; and being a strong-bearded grain, it is well defended against the ravages of the birds, which, near villages and inclosed countries, is no inconsiderable advantage.

XL.

On the Culture of Cabbages.*

In a field from which I gathered last year a prodigious crop of turnips, amounting to one hundred tons per acre, (Cheshire measure) I this year have raised cabbages. The land was ploughed into ridges of three and a half, or

---

* By T. B. Bailey, Esq. F. R. S.

four feet, and each ridge prepared with manure as for potatoes, i. e. the dung or litter was only laid under the middle of the ridge. The plants, raised from seeds sown in August, 1772, and transplanted on beds in October following, were set out in this field at the distance of about two feet and a half, or three feet, in March and April; were once hand-hoed and twice horse-hoed through the summer, but were greatly retarded in their growth by the excefsive heats and dry weather in June and July. The number of plants set out on a Cheshire acre was near eleven thousand.—As a great quantity of my autumn plants were killed in the winter, I sowed more seed in February; but this year's experience, added to that of the preceding ones, has convinced me, that it is absolutely in vain to expect a weighty crop of cabbages from spring plants. The sorts I sowed were the North American and Scotch; but I find that the Scotch is, on all accounts, preferable, and far more durable.

In the month of November, I took up and weighed a square rod, or sixty-four yards, containing sixty-eight cabbages, of which fifteen or twenty were small, being spring plants. The weight was 1211 lb.—on an average 17 lb. or eighty-six tons ten hundred.—Taking out fifteen spring plants, at 2 lb. each, out of the above number sixty-eight, the average will be 22 lb. or 103 tons to the Cheshire acre, and this, I take, will not much exceed the acreable produce of my autumn-sown plants.—Supposing, therefore, that, on a medium, each cow or ox eats half a ton a week, or 143 lb. each 24 hours, and that this keep is only worth 4s. per week, an acre of cabbages, as above, at this estimate, will be worth 41l. per acre; but at the first calculation of 86 tons ten hundred, it will be worth 34l.

EXPENSES.

Rent, - - -	£3	10	0
Manure, - - -	5	0	0
Two ploughings, -	1	0	0
Plants, - - -	4	0	0
Setting, - - -	0	8	0
Hand-hoeing - -	0	4	0
Two Horse-hoeings, -	0	10	0
Harrowing, - -	0	3	0
	14	15	0
	34	0	0
	19	5	0

In the account of expenses I have rated them beyond the truth, and have estimated the land at an high value; but it will be objected, that 5l. an acre is not enough for manure; I answer, more than enough for land rich like mine; but allowing 12l. an acre, still the profit will be 12l. 5s.

This account will, I hope, prevail on others to make trial of these plants. They come to their perfection when the eddish is over, and greatly exceed turnips in feeding either fat cattle or milk cows, and are not only to be sought for, as they are an excellent food, and produce much dung, but as they save hay, which, in general, is very dear and scarce in this country, and does by no means produce so much milk, or fat beasts so well. Will four shillings a-week keep a large cow in fine order when hay is 6d. per stone? and it is often more.

XLI.

*The Method of using Sea-Weed in Scotland**.

Of sea-weed there are three different kinds. The best is that which is cut from the rocks,

---

* By Sir A. Purves, Bart.

and of which kelp is made. The second-best is called the peasy sort. The worst is that with a long stalk. All these kinds are used in Scotland, but chiefly for the barley-crop, in which case, or for fallow, it is ploughed in directly. The people of the country have so high an opinion of its fertilizing quality, that they sometimes lay it on after the barley is in the ground, but that is a slovenly and injudicious method. In the neighbourhood of Berwick, it is used in their compound dunghills, with fold-yard, stable-dung, and earth; and in that manner an immense quantity of dung is produced by such farmers as are situated near the sea. In that neighbourhood, the farmers are very intelligent; and it is a pity that such excellent management should be so little known in many parts of the northern coast of England, where the sea-weed is produced in great abundance. It is remarkable that such farmers as use the sea-weed properly, have their lands in such heart as seldom to have occasion for a fallow to restore their freshnefs. This species of manure is experimentally found to be excellent for gardens, as it not only enriches the ground, but also destroys all kinds of vermin.

XLII.

The Method of preparing Land for sowing Lucern broad-cast.*

It having been found by repeated experiments, that broad-cast lucern will not succeed upon lands that are not perfectly clean, I determined upon the following method of preparation, which has succeeded beyond my most sanguine expectations.

In the month of August, 1771, I mowed the grafs from one acre three roods of land intended for lucern, and immediately after the hay was removed, I pared and burnt the surface. The ashes were put into two heaps, and covered with sods, to prevent the influence of the air upon the salts produced by this operation. The ground was then ploughed as deep as its staple would admit of. On the 11th of November I harrowed it with heavy harrows, and on the 25th I ploughed it acrofs. On the 4th of January, 1772, it was harrowed again. One heap of the ashes was spread on the 23d of March, and on the 2d of April the land was ploughed and sown

* By A. St. Leger, Esq.

with lentils. Had the weather permitted, I should have sown immediately upon spreading the ashes. About the beginning of August the lentils were cut, and the other heap of ashes was spread upon the surface; after which the land was ploughed, and immediately sown with turnip-seed. The turnips were well hoed, and produced an exceeding good crop. Being late sown, they consequently kept later in the spring than such as were sown at the usual season.

From this mode of management, I dare say that no land was ever in a better state for the Norfolk course of crops—of all others the most rational and profitable. But as my design is only to give the best method of preparing land for sowing lucern broad-cast, I shall drop any observations upon the propriety of the Norfolk husbandry, viz. turnips, barley, clover, and wheat. The exact estimate of the expense incurred by my management is as follows;

Two years rent, - -	£1	8	0
Mowing and getting the hay,	0	7	0
Carried forward,	1	15	0

Brought forward, £	1	15	0
Paring and burning, - -	1	10	7½
Ploughing three times, -	1	4	0
Harrowing, - - -	0	5	0
Gathering the ashes into heaps,	0	15	0
Spreading ditto, - -	0	10	0
Lentil and turnip-seed. - -	0	15	0
Mowing and getting the lentils,	0	9	0
Hoeing turnips, - -	0	7	0
	7	10	7½
Produce of hay. - -	6	0	0
Ditto of lentils, - - -	4	0	0
Value of turnips, - -	3	0	0
	13	0	0
	7	10	7½
Profit,	5	9	4½

In May, 1773, I sowed the field, broadcast, with lucern-seed, after being properly ploughed.and harrowed. The quantity of seed twelve pounds per acre, which I recommend to be sown at twice, in order that the seed may be the more equally distributed upon the surface. Every time that the lucern is cut, the land must be run over by the harrows, to tear up the grafs and weeds that otherwise would eat out the lucern. The year after sowing, the plants should be hand-weeded, being then very tender; but the succeeding years, when the roots have firmly penetrated the soil, the heaviest harrows may be introduced, without a pofsibility of injuring the plants.

After the frosts are over, and vegetation begins, the lands may be harrowed, if foul; but if clean, that operation will not be required till after the first cutting. At this present time, (August 1775) I am cutting the third crop, and expect another cutting this season. With the above preparation of the land, and a proper attention to the lucern after being sown, there is no doubt but that this foreign grafs will be a means of improving the British Husbandry, by liberally supplying our cattle with green forage of a most luxurious and nourishing nature.

XLIII.

*On Transplanting Potatoe Tops**.

On the 18th of May, 1772, finding some beds I had sown very early with onions to be

* By Mr. Elleray, near Manchester.

a mifsing crop, I was induced to make the following experiment. The year before, I had set some potatoes in another part of my garden, in the common way; and as it is impofsible but some will remain in the ground all winter, so I found a number of sprouts about three inches high, which I nipped off close to the ground, and transplanted them into the onion beds, without any further preparation, about a foot and a half asunder, in the same manner that cabbages and cauliflowers are planted. As the season became immediately very dry, I was obliged to give my plants a little water for four or five succefsive nights; after which they began to flourish, and had the appearance of a promising crop during all the summer. At the usual time, in October, I ordered them to be taken up; and for size, quantity, and quality, they exceeded all I ever had in the common way. Had the ground been fresh, properly manured and prepared, and the plants put down at a proper distance from each other, I am of opinion that the succefs would have been still greater. Cuttings from the full grown plant will take root in the same kindly manner, if gently watered when put down.

Both these experiments are, however, but matters of curiosity.

XLIV.

*On nutritive Lime**.

Take twenty-four bushels of slaked lime; train-oil foot, sixteen gallons. Mix these together, taking care that the lime be sufficiently cold before the oil is added. This quantity is thought sufficient for an acre of winter or spring corn. It is intended to supply the place of rape-dust, and should be put upon the land in the same manner. It may also be recommended as a top-drefsing for wheat in the spring; the earlier the better. From the few trials that have been made upon this compost, it appears to be pofsefsed of considerable nutritive powers; but as nothing should be adopted as a truth in agriculture, which has not stood the test of numerous trials, the above compost is recommended as an object worthy of future experiment. It is also recommended to gardeners as a top-drefsing for all kinds of seeds, as it is presumed that it will prevent the mischiefs

* By A. Hunter, M. D.

occasioned by insects. By the experiments of Mr. Townley, of Belfield, near Rochdale, the oil-compost is found to be of great use in raising large crops of onions. This nutritive lime being upon the same principles, and much easier of preparation, will probably answer the same purposes. It will here be proper to remark, that light soils are best managed by top-drefsings: Stiff lands require lime and plenty of rotten dung to break the cohesion of their particles. This distinction should be seriously attended to by the cultivators of land, who wish to enlarge their understandings by tracing effects up to their proper causes.

XLV.

*On feeding Hogs with Potatoes**.

From an accurate experiment made last year, I dare venture to recommend baked potatoes as an excellent food for hogs. The pork produced by this food, was equal to that from barley and beans; but at present I cannot exactly ascertain the comparative experiment with regard to expense; however, I am of opinion that roasted potatoes, considering

* By Mr. Charles Chaloner.

the improvement of the hogs, is as cheap a food, if not cheaper, than can be given them. I roast my potatoes upon a kiln, similar to what is used by oat-meal shellers for drying their oats. The difference in expense between boiling and roasting the potatoes is prodigious, both with regard to the labour and fuel. A kiln that will cost 3l. will roast potatoes sufficient for the maintenance of more than 20 hogs ; and one man will bestow all the necefsary attendance upon them, and do other work besides. The action of the fire, by difsipating the crude juices that are contained in raw potatoes, reduces them into a state highly wholesome and nutritious. Boiling does this in part, but not so effectually. A potatoe roasted in the manner above described, partakes much of the nature of a chesnut, and perhaps is not greatly inferior to it.

XLVI.

*A Comparison between Red and White Wheat**.

It is a mistaken notion in those who buy wheat for family use, to give the preference

---

* By Mr. E. Cleaver, of Nunnington, near York.

to the white sort, it being a demonstrable fact, that the red is considerably heavier. It is moreover of such a strong body, that provided you weigh 100 lb. of the flour made from white wheat, and 100 lb. from red wheat, the latter by taking a greater quantity of water, will make a larger weight of bread. This circumstance is known to few, except bakers and corn-dealers, who, in many of the country markets, buy the red wheat at 8d. and sometimes 1s. per bushel under the price of the white and weaker kind.

XLVII.

*On the best Method of raising Early Potatoes**

As the culture of potatoes, and particularly of the early sorts for the table, has of late become an object of very general attention, I hope the following account of a new method of obtaining these (without the help of hot-beds) will be acceptable to the public.

On the 2d of January, 1772, I made a hot-bed for the forward sort of potatoes, and on the 7th put in the sets, placing a glafs and frame

* By Mr. M. Kirk, of Wilderspool, near Manchester.

over them, and taking every precaution to defend them from the frost. Of these small potatoes, or sets, their remained about forty in a basket, which was accidentally hung up in a warm kitchen, and there remained unnoticed till about the 25th of April. I then accidentally observed the basket, and perceiving something green on the edge of it, took it down, and, to my great surprise, found that the potatoes had sprouted half a yard in length, and that there were a great number of very small potatocs formed on the fibrous roots which had grown out. I took them into my garden, and planted them in a rich sandy soil, without any manure. The roots I put into the ground three inches deep, and laid down the stems that had sprouted, horizontally, and covered them with two inches of soil, but left the tops uncovered. Without farther attention they grew surprisingly.

On the 26th of May, I took up the roots planted in the hot-bed on the 7th of January. They by no means answered my expectations, or paid for the trouble of their culture: But at the same time, I was astonished to find the others, which were put into the ground so late, to have produced larger potatoes than the roots in the hot-bed. I took up all the roots, and picked off the large potatoes from them, which amounted to from 4 to 12 on each root, and then set the roots again on the same ground. This, indeed, I have succefsfully practised for many years, sometimes even twice, and have had a good third crop at Michaelmas. When this method is tried, the roots must be watered on the evenings of hot days.

In January, 1773, in order to make a second trial of this experiment with a large quantity, I placed a great many potatoes of the early sorts on a thick layer of gravelly soil, close to each other, over an oven, slated over, but open to the south-west, and covered them two inches deep with the same earth.

At the end of April I took them up, and found the stems about a foot long or more. For fear of injuring the fine and delicate fibres of the roots, I took great care in taking them up, and planting them in the soil. This I now manured, but in all other respects treated them in the manner above described, many of the fibrous roots having then potatoes formed upon them, nearly as large as walnuts. For a week the plants came on surprisingly, when, by one sharp night's uncommon frost, they were nearly destroyed. However, notwithstanding this, fresh stems grew up in a few days, and I actually gathered from them, on the 3d of June following, finer potatoes than were sold at that time, at Manchester, from 1s. to 1s. 6d. per lb. being the produce of hot-beds.

After taking off the larger potatoes, I again planted the roots for a second crop, and in September obtained a very large produce. I weighed the increase of many separate roots, which amounted from 4 lb 8 oz. to 14 lb. 12 oz. the potatoes being the largest of the forward kinds I ever saw.

XLVIII.

On Limc.*

From the repeated succefs I have had in liming of land, I am induced to relate an experiment, which I am convinced may be attended with as much public utility, as it has been productive of my own private advantage.

In the year 1765, I ploughed up a piece of lean swarth, containing 18 acres, which, to all

---

* By Mr. E. Cleaver, of Nunnington, near York.

appearance, had it been sown with oats, would not have produced above 3 quarters per acre. The quality was a wet, cold clay, not very stiff, but spungy, and worth about 10s. an acre, tithe-free. It will be proper to mention, that, in the time of the distemper amongst the cattle, it was under the plough, and continued in tillage till it would scarce bring the seed again; after which it was suffered to lie down without either grafs-seeds or manure, and consequently had no chance to improve but by rest and length of time.—This, as near as I can describe, was the quality of the land.

My course of husbandry was as follows: Early in the spring I ploughed it out of swarth, and laid on 167 chaldrons of lime, 32 bushels, upheaped, to the chaldron. The whole was laid on immediately after the first ploughing, or as soon as I could get it burnt and led to the land. After being four times ploughed, and well harrowed between each ploughing, I sowed the whole 18 acres with rape. From the leannefs and toughnefs of the swarth, I could not get it into proper order; so that towards the time of the wheat ripening, rapes put up in the places where the crop was thinnest, and did me considerable damage. I have observed that I laid on 167 chaldrons of lime upon the whole 18 acres; which is at the rate of 9½ per acre; but as I had a desire to know the effect of the lime in different proportions, I divided the field into two unequal portions, N° 1. and N° 2. On N° 1. (7 acres) were laid 84 chaldrons, which is 12 chaldron per acre; on N° 2. (11 acres) were laid only 83 chaldrons, which is about 7½ chaldrons per acre.

The acreable Produce for three Crops.

N° I.	l.	s.	d.
1770. Rape, (4 ploughings) 32 bushels, at 20 l. per last,	8	0	0
1771. Wheat, (1 ploughing) 50 stooks, or 40 bushels, —	12	0	0
1772. Oats, (1 ploughing) 68 bushels; but would have been more had not the harvest proved remarkably wet, whereby one fourth of the crop, at least, was lost,	5	19	0
Produce of 3 crops,	25	19	0

Nº II.	l.	s.	d.
1770. Rape, (4 ploughings) 24 bushels,	6	0	0
1771. Wheat, (1 ploughing) 32 ditto,	9	12	0
1772. Oats (1 ploughing) 68 ditto,	5	19	0
Produce of 3 crops,	21	11	0
Produce of Nº 1.	25	19	0
Ditto of Nº 2.	21	11	0
Difference in 3 crops,	4	8	0

It must here be remarked that the oats on this part were cut first, and did not receive so much damage by the wet season as Nº 1. otherwise they were not near so strong.

As I burn my own lime, it does not cost me above 7s. 6d. per chaldron; so that the whole 12 chaldrons are paid for in three crops by the extraordinary produce, and the land left in better condition by three or four shillings per acre.

I would not have it understood that all land can bear an equal quantity of lime with what I have here mentioned. Whoever tries the experiment on old tilled land will find himself in an error, especially if the soil be clay, which is apt to be too much bound after the fermentation of the lime is over—but sand lands can never be over-done with lime, provided it be laid on in the spring, and not of that fiery kind which many of the sorts are. Lime differs in quality as well as land itself. In many countries the crops would be burnt up if two chaldrons were laid on an acre; whereas in Derbyshire there are instances of people laying on 12 and 14 chaldrons per acre on graſs land.

As this quantity of lime exceeds any experiment I have heard of in this country, I am apprehensive the farmers in general will not give credit to it; however, I attest it as a fact; and as it is a thing of much consequence, I shall have a particular pleasure in having it confirmed by similar experiments.

XLIX.

*On preparing Seed-Wheat with Oil**.

The autumn of the year 1770 being remarkably wet, and a bad time for sowing wheat, whereby many acres of land could not be con-

---

* By Mr. E. Cleaver, of Nunnington, near York.

verted to the intended purpose, but were obliged to be cropped with oats or barley in the spring; I was induced, through the prospect of a great scarcity of wheat, to sow down five acres of land at Candlemas, after eating off a crop of turnips with sheep; and as the season continued extremely unfavourable, I had recourse to the following preparation of my seed, with a view to counteract the wetnefs of the season: I put a pint of fish oil, and 3 lb. of salt, to every bushel of seed; and as the birds at that season would of course be troublesome, I sowed three bushels and a half of seed to the acre. I had a further reason for bestowing this *additional*, or rather *extraordinary* quantity of seed, which was, that the thicker the corn came up, the lefs it would gather, and consequently would ripen quicker. My seed was the common Red Lammas, which is the hardiest as well as the heaviest sort. The produce was 245 stooks (or 45 stooks to the acre) which yielded as follows:

		B.
30 stooks, threshed out at Michaelmas, produced —	3	0
30 ditto at Candlemas, ——		27
30 ditto in May, —— —		24
		81

From the computation of 90 stooks to 81 bushels, the whole crop of 245 stooks would yield 220½ bushels, or 44 bushels to the acre. The straw was about 24 thraves per acre, and sold so high as 1s. 6d. per thrave, which is 1l. 16s. per acre, though the average price of straw, in this country, is not 1s. per thrave.

VALUE.

44 bushels, at 6s. each,	£13	4	0
24 thraves, at 1s. 6d each	1	16	0
Per acre,	15	0	0

From the experiment of the proof of the corn by the stook, it plainly appears that, between Michaelmas and May-day, the farmer loses in measure 6 bushels in 30, or $\frac{1}{5}$ part, by the mere pining of the grain.

I find this method of steeping seed-corn in oil was formerly practised by the Romans.

Semina vidi equidem multos medicare serentes,
Et nitro prius, et nigrà perſundere amurcâ,
Grandior ut fœtus siliquis fallacibus eſset.

Virg. Georg. lib. i. l. 193.

There is reason to believe that this procefs of oiling the seed will be found highly serviceable in wet seasons, and perhaps at all times may contribute to the enriching the farina of the grain, which we know, from experiment, constitutes the nourishment of the tender germ.

L.

On Dibbling Wheat *.

It is now become very common in the county of Norfolk to dibble their wheat instead of drilling, or sowing it broad-cast. The advantages of this method are numerous. It secures a clean crop of excellent seed, and saves to the community an enormous quantity of wheat, that inevitably must have been consumed and lost in the common method. It besides finds employment for the women and children, at a time when their afsistance is not required by the farmer for other purposes. Their labour is therefore a clear gain to the public. It has been objected, that if this method should become general, the farmer could not procure hands to put his work sufficiently forward. I readily grant that the villages could not sufficiently supply the necefsary hands, but it should

* By John Curzon, Esq.

be considered, that, where work is certain, numbers of people are invited from towns and other remote distances. I need produce no arguments, after mentioning the facility with which hands are procured for the gathering saffron and hops. Previous to setting the wheat, the land must be ploughed and manured as for a crop of broad-cast grain. After harrowing it well, and smoothing the surface with a light roller, it is prepared for setting, which is performed by making holes with a kind of dibble used for pease, the man working backwards, and the women and children following, and dropping two or three grains of wheat into each hole. The dibbles are so contrived, that a man may, with one stroke of his foot, make three or four holes at once—the holes about seven inches asunder, and two inches deep. After the whole ground is set, a light harrow must be introduced to fill up the holes; and when the weeds advance, some turnip-hoers must be employed to stir the ground and cut down the weeds; after this, no further care is required till the harvest, when the farmer may be afsured of a plentiful and clean crop, in reward for his extraordinary attention. Two pecks of wheat will set an acre; the price of labour about eight shillings. It is now become a common practice to dibble wheat upon a clover lay after a single ploughing.

LI.

*On Claying Land**.

Where the land has never been broke up, the clay may be carried and spread, and suffered to lie a whole year before it is ploughed in. The flag will set the clay a-working; but where there is no flag, a coat of dung will be necessary before the land is sown. Where the clay is short, and the soil light, 120 loads will be required for an acre; but where the clay is strong, and the land not so light, then 60 or 80 loads will be sufficient. It is better to lay on too little than too much; it will be sufficient if the land is made moderately cloddy. About a cubical yard of clay makes a load. Carry the clay at any convenient time of the year. If time permit, carry it after harvest, and lay it upon a wheat stubble; there let it remain spread all the winter. In March, plough it in; again in May, and twice in June, and sow turnips about Midsummer. In Norfolk

* By the Rev. Mr. Buxton, Norfolk.

they formerly paid one guinea for filling and spreading 120 loads of clay, but now (1772) they are obliged to allow something more.

LII.

On Siberian Barley.*

It is not yet determined what kind of land is most suitable for the cultivation of Siberian barley. From the weight of the grain, it would seem that it requires good rich land; and indeed my experiment, when compared with others made upon poor land, seems to me very decisive in favour of a rich soil. In the first week of April, 1774, I ploughed half a rood of land that the year before had borne a crop of cabbages, and sowed it with a bushel of Siberian barley. The soil a rich hazel earth. The crop was reaped before the common barley. The product seven bushels.

LIII.

A comparative View of Manures†.

In the year 1771, I marked out a rood of land into divisions, and sowed them with oats. The variety of manures made use of in this experiment are marked as follows:

---

* By Mr. Wright of Craike.

† By A. Young, Esq.

PROPORTION PER ACRE.

No.	Manure	Produce per Acre B.	P.
N° 1.	40 cubical yards of farm-yard compost, earth, and dung,	40	$2\frac{1}{2}$
2.	20 ditto,	51	1
3.	10 ditto,	45	0
4.	10 ditto,	46	1
5.	10 loads of bones, each 40 bushels	63	1
6.	20 ditto,	57	0
7.	200 bushels of lime,	38	$1\frac{3}{4}$
8.	40 yards of chalk,	31	1
9.	No manure,	30	$2\frac{1}{2}$
10.	80 yards of chalk,	25	$2\frac{1}{2}$
11.	120 ditto,	27	2
12.	40 ditto, earth mixed with train-oil, six months ago, and often turned,	33	$0\frac{1}{2}$
13.	40 ditto, earth mixed with urine, four months ago, and often turned,	37	2
14.	40 ditto, earth alone,	33	$0\frac{1}{2}$
15.	40 ditto, earth from the farm-yard,	35	0
16.	120 ditto, red gravelly loam,	29	$1\frac{1}{2}$
17.	160 ditto,	31	1

N. B. The season was remarkably dry, which circumstance certainly had a considerable effect upon the different crops.

LIII.

*On Potatoes**.*

When potatoes are planted on land that has a disposition to too much moisture, especially when the summer is wet, it generally happens that the crop is injured by water standing in the furrows between the rows. In land so circumstanced, it is a a juicious practice to plant the potatoes acrofs the ridge, which will effectually prevent the water from injuring the crop by giving it a ready descent into the furrows that divide the lands.

LIV.

*On fatting Hogs**.*

As there were some young hogs that we wanted to keep over the summer, seven of the largest were put up to fat on the 25th of February. They were fatted upon barley-meal, of which they had as much as they could eat; some days after, the observation of a particular circumstance suggested the following

---

* By Gilbert Crompton, Esq.

† By the Earl of Egremont's Steward.

experiment, A hog, nearly of the same size as the seven, but who had not been put with them because they appeared to be rather larger, but without weighing them, was confined on the 4th of March, in a cage made of planks, of which one side was made to move with pegs, so as to fit exactly the size of the hog, with small holes at the bottom for the water to drain from him, and a door behind to remove the soil. The cage stood upon four feet, about a foot from the ground, and was made to confine the hog so closely, that he could only stand up to feed, and lie down upon his belly. He had only two bushels of barley meal, and the rest of his food was boiled potatoes. They were all killed on the 13th of April, and the weights were as follow, (8 lb. to the stone:)

The hog in the cage, 13 st. 2 lb. The other hogs, all of the same breed,

12 st.	2 lb.
12	3
11	2
11	4
11	4
11	2
12	2

The hog in the cage was weighed before he was put in; he then weighed, alive, 11 st. 1 lb. He was kept five weeks and five days, and then weighed, alive, 18 st. 3 lb. He eat two bushels of barley-meal, and about eight bushels of potatoes. He was sulky for the two first days, and would eat nothing.

ESSAY V.

On the most profitable Method of managing light Arable Lands.

A Judicious course of crops constitutes a most efsential part of an arable farm. The following is practised in Norfolk, a country remarkable for the best courses.

First Year——TURNIPS.

1. Plough the stubble up about Christmas.

2. The beginning of March, plough again and harrow.

3. The beginning of April, plough and harrow; but before you begin to plough this third time, spread twelve loads of good manure upon each acre.

4. Plough again a fortnight before Old Midsummer; then sow your turnip-seed, two pints to an acre, and harrow it in.—Hoe the turnips twice.

Second Year.——BARLEY and CLOVER.

Get the turnips off the beginning of March—plough and harrow. Three weeks after, plough and harrow again. The latter end of

April, or beginning of May, plough the third time; but before you begin to plough, sow half of the seed upon the land, namely, a bushel and a half per acre, then plough and sow the same quantity of seed above furrow. Harrow once; then sow ten pounds of good clover-seed, and let the barley and clover be harrowed in together.

Third Year——CLOVER.

Take two crops of clover; or, if you think proper, reserve the second crop for seed.

Fourth Year——WHEAT.

A fortnight, or three weeks, after Old Michaelmas, plough your land. As soon as ploughed, throw two chaldrons of hot lime upon each acre. Harrow the lime and the seed in together. Provided the land be clean, I think two bushels of wheat or barley sufficient seed for an acre.

Expense of the Turnip Crop.

	l.	s.	d.
Four ploughings and harrowings, at 3s. 6d. each	0	14	0
Twelve loads of manure, and carriage, at 5 s. per load	3	0	0
Seed, 2 pints, 1s. Hoeing twice, 7s.	0	8	0
	4	2	0

Expense of Barley and Clover.

	l.	s.	d.
Three ploughings and harrowings, at 3s. 6d. each	0	10	6
Seed, two bushels, 5s. Clover 10s.	0	15	0
Reaping 1s. 6d. Beer 1s. 6d. Getting in 5s.	0	8	0
	1	13	6

Expense of the Clover Crop.

	l.	s.	d.
Cutting and beer 2s. Making 1s.	0	3	0
Carrying 5s. Second crop 7s. 6d.	0	12	6
	0	15	6

Expense of the Wheat Crop.

	l.	s.	d.
Ploughing once and harrowing -	0	4	0
Lime, 2 chaldrons, 1l. Carriage 10s.	1	10	0
Seed, two bushels —	0	10	0
Reaping 6s. Beer 1s. 6d. Carrying 5s.	0	12	6
	2	16	6

Expense of the four Years.

	l.	s.	d.
Turnip crop — —	4	2	0
Barley ditto — —	1	13	6
Clover ditto — —	0	15	6
Wheat ditto — —	2	16	6
	9	7	6

	l.	s.	d.
Nine pounds seven shillings and sixpence, for four years, makes each crop, upon an average,	2	6	10½
Add rent 1l. Tithes and rates 7s. 9d.	1	7	9
Rent, rates, and cultivation per acre	3	14	7½

Profits of four Crops.

	l.	s.	d.
Turnip crop worth —	3	0	0
Barley ditto, 36 bushels at 2s. 6d.	4	10	0
Clover ditto, first crop, three loads	3	0	0
Second ditto, two loads —	2	0	0
Wheat ditto, 28 bushels at 5s.	7	0	0
	19	10	0

	l.	s.	d.
Nineteen pounds ten shillings, makes each crop upon an average — —	4	17	6

		l.	s.	d.
Profit per acre	— —	4	17	6
Expenses	— —	3	14	6
Clear profit per acre		1	3	0

Lands cultivated in this manner will never be over-run with weeds; neither can the ground be distrefsed, as tap-rooted plants regularly follow such as spread their roots superficially. —The system is founded on reason, and supported by experience. Nice farmers dibble in the wheat, dropping three grains into each hole. For this practice a clover lay, after one ploughing, is the most favourable.

ESSAY VI.

On the Sexes of Plants.

WHEN we unfold the volume of nature, the human mind may very justly be compared to a bee unable to settle amidst a variety of sweets. Every page presents us with a subject inexpressibly pleasing, and every object fills us with admiration as well as delight. We are at a loss to acknowledge the existence of a Supreme Being, or the benign influence of that Being in providing for the happiness and convenience of his creatures, in stronger terms.

Every person who takes a view of nature in this light, must undoubtedly conclude, that as the wants and conveniences of life were designed to be supplied ftom the storehouse of nature, from the very moment that man started into existence, so the means for executing that design on the most advantageous terms, must be a laudable as well as necessary undertaking.

Man, above all other creatures, is blefsed with a power of improving his understanding, and his actions, to an amazing degree of perfection. And he that is desirous to drink clear water, rather than muddy and corrupted, usually neglects the distant stream, and prudently repairs to the fountain head, where the element flows pure and unadulterated.

In arts and sciences, the practical part will be conducted upon a vague and uncertain plan, till the theoretical be founded upon rational and consistent principles. The economical part of nature depends much upon the phisiological; and even in common life, causes must ever be prudently adjusted, if we expect their consequences to be pleasing. It is this that has led on science, through the different periods of time, to the height she has now arrived at; and it is this that, in future ages, will render the improvement of the present æra, admired, carefsed and imitated.

The present century is very remarkable for its various improvements in natural history, among which agriculture deservedly claims the foremost rank. And since agriculture has been reduced to a regular science, and its principles established upon facts and experiments, it has made a commendable and extensive progrefs. We every day experience the most pleasing effects from the industry of men of literature and ingenuity, who are continually taking up the pencil to fill up the outlines of so grand a design. Much has already been done, and yet a great deal remains to be executed. Nature unfolds not all her treasures at once, but is slow and gradual in her operations. The hyacinth and the tulip require the warmth of many revolving suns to produce their inimitable beauty and attire!

The labours of the great Linnæus can never be sufficiently admired; and his endeavours to new-model the study of nature, have already exceeded the most sanguine expectation. He has sketched out the philosophy of nature so strongly, that he is every where considered as the wonder of his age. The subject of this efsay, in particular, owes much to his penetration; and though he does not claim the sole merit of discovering the sexes of plants, yet he deserves our utmost acknowledgements for having brought all the arguments in favour of it into the clearest point of view. It is now a truth too glaring to be denied.

We find that the ancients were by no means strangers to the notion of the sexes of plants; and though their writings do not bear any very strong evidence in their behalf, yet their observations and their practice clearly demonstrate it. They appear to have been perfectly satisfied that nature pursues the same plan of preserving the species in the vegetable, as in the animal world: That male and female are as distinct in the one kingdom as the other, and that they are governed by similar laws.

Herodotus tells us that the Babylonians, in cultivating the Palm-tree, with which their country was plentifully stored, were forced to gather the flowers of the male tree, and carry them to the female, if they expected to reap any fruit; but their notions went no further than the customary practice. Theophrastus, in his history of plants, observes that some kinds of trees were distinctly male and female, and strengthens his supposition by adding that the one bore fruit, and the other was barren.

It is amazing that nothing material should have been struck out upon the subject from Theophrastus's time till Sir Thomas Millington, Savilian Profefsor of Astronomy at Oxford, towards the clofe of the last century, revived the notion, and cleared the way for the experiments of the celebrated Grew. Since that time many able naturalists have discufsed the point with clearnefs and precision, among whom our illustrious countryman, Mr. Ray, appears with Camerarius, Moreland, Geoffroy, Vaillant, Blair, Bradley, and others.

This new doctrine met with some considerable opponents. Monsieur Tournefort was a violent adversary; and Dr. Alston, the late Profefsor of Botany at Edinburgh, mustered all his forces in the opposition.

The critical reader will be much pleased with the anatomical description of the parts of flowers, and the nice difsection of their organs of generation, in Grew's Anatomy of Plants, Linnæus's Philosophia Botanica, and in the Sponsalia Plantarum in the first volume of the Amænitates Academicæ, to which I refer him. But however obvious the sexes of plants may appear in some clafses in the *same* flower, in others in *different* flowers, and in others upon *different* plants, yet I fear the peculiar mode of operation, by which nature ultimately effects her generations in the vegetable world, will continue a secret so long as the theory of *animal* conception remains undetermined. All that seems useful to us is already discovered; and let man, the finite creature of an hour, leave the rest to the Author of Nature to disclose, by those gentle degrees which always terminate in some unforeseen bounty and munificence.

In the 47th volume of the Philosophical Transactions, there is a letter from Mr. Mylius of Berlin, dated from thence February 20, 1750-51, to Dr. Watson, which was presented to the Royal Society by the Doctor in the succeeding year, and published by him, with his own observations, in the Transactions. It contains a proof of the sexes of plants, from an experiment made on the Palm-tree. The singularity of the experiment will apologize for its appearance in this efsay.

“ The sex of plants is very well confirmed by an experiment that has been made here on the *Palma Major foliis flabelliformibus.*

There is a great tree of this kind in the garden of the Royal Academy. It has flowered and borne fruit these thirty years, but the fruit never ripened, and when planted it did not vegetate. The Palm-tree, as you know, is a *Planta Dioecia*, that is, one of those in which the male and female parts of generation are upon different plants. We having no male plants, the flowers of our female were never impregnated by the *farina* of the male. There is a male plant of this kind in a garden at Leipsic, twenty German miles from Berlin. We procured from thence, in April 1749, a branch of male flowers, and suspended it over our female ones, and the experiment succeeded so well, that our Palm-tree produced more than an hundred perfectly ripe fruit; from which we have already eleven young Palm-trees. This experiment was repeated last year, and our Palm-tree bore above two thousand ripe fruit. As I do not remember a like experiment, I thought it convenient to mention it to you; and if you think proper, be pleased to communicate it to the Royal Society."

A person who is a *stranger* to natural, and more particularly to botanical knowledge, may make himself an entire master of what is meant by the sexes of plants, and form an accurate idea of the mode of generation, in the grofs, whose garden produces a single tulip. When the flower opens, if he looks within the leaves, or, to speak in the language of botanists, within the *petals*, there will be found six slender erect chives, or *stamina*, surrounding a three-squared stronger body, called the *pointal*, or female part of the flower. Upon the top of each of the *stamina* hangs a small oval body, which, in a day or two after the flower is blown, may be observed to burst into a mealy substance. This meal, or *farina*, is the male part of the flower, and by the action of the wind is blown upon the *pointal*, or female part of the flower, which is furnished with a viscous kind of matter, designed by nature to retain the male *farina* when blown upon it. From this moment the impregnation takes place, and the seed is produced perfect and entire.

As a further proof of the necefsary influence of the male *farina*, only pinch off the male part of the flower before the *farina* begins to burst out, and the female part will, at the usual time of expecting the seed, present the examiner with nothing but an abortive seed-vefsel.

In most vegetables the male and female organs of generation appear in the *same* flower; but in some plants there are male and female flowers on *separate* parts of the same plant; and in other plants, the male flower appears on *one* plant, and the female on *another*.

From these premises, the improvers of agriculture, and even the common practical farmer, may be able to deduce very useful consequences. If the farmer dreads heavy and sudden rains, immediately after he has sown his seed, he may, with equal reason, be afraid of them at the time his corn is in bloom. For, as the wet will injure him in one case by bursting the seed, so it will in the other by washing off the *farina*, or male dust, whereby an effectual impregnation will be prevented. The farmer will not then be surprised if his grain appears small and pined at the time of threshing, when he can so readily account for the cause in philosophic terms.

But the principal use that will accrue to the gardener and the farmer from the discovery of the sexes of plants, will be the hints they may gain in regard to saving the different kinds of grain for seed. It is always an object with the judicious cultivator to throw fine bold seed upon the earth, if he expects the produce to gain him credit in the market. And certainly if the winds have such an effect upon the *farina* of flowers, as not only to waft it upon the female flowers of the *same* species, but even upon *different* species, care should be taken that the cabbage tribe, if designed for seed, should be cultivated at as great a distance from each other as poſsible, to prevent the ill consequences of a *mongrel* produce.

Mr. Miller, in his Gardener's Dictionary, prescribes this caution to the cultivators of cabbages, cauliflowers, turnips, brocoli, &c. in very strong terms. For if they expect the several kinds to be perfect, these plants must by no means be set near each other when designed for seed, because, in that case, the *farinas* will undoubtedly incorporate, and produce a *bastard*, or imperfect kind of each species. Mr. Ray, in his History of Plants, tells a remarkable story of a gardener, one Richard Baal, of Bramford, who had sold cabbage-seed to the London gardeners as of an excellent kind, but unluckily, when sown and cultivated by them, produced an exceeding bad kind. The consequence was, that the man was prosecuted in the courts of justice at Westminster, and sentenced to return the money he had taken for the seed, and also to satisfy his customers for their waste of ground, time, and labour; though, in fact, he was not at all deserving of such a sentence, not having had the least design to impose upon them.

Nothing is so common as for gardeners in the raising of melons and cucumbers, at the time of the flowering of those plants, to pinch off what they call the *barren* flowers, lest the quantity of fruit should impoverish its size. But for want of knowing that these plants produce male and female flowers *separate* upon the same plant, and that no fruit can be expected unleſs there be a communication of the two sexes, it is no wonder that their crops frequently fail.

It may not be amiſs to close this eſsay, by pointing out some of the principal plants, in our own country, where the fructification varies from the usual form.

1. Male and female flowers on the same plant. Linnæus's 21st Claſs, *Monoecia.*

The Carex tribe of grafses.
Birch tree.
Alder.
Box.
Burnet.
Chesnut tree.
Beech.
Hornbeam.
Hasel-Nut tree.
Firs.

2. Male and female flowers on separate plants. Linnæus's 22d Clafs, *Dioecia.*

Willows.
Mifseltoe.
Buckthorn.
Hops.
Black Briony.
Poplars.
Dog's Mercury.
Juniper.
Yew tree.
Knee-Holly, or Butchers Broom.
Hemp.

3. Flowers hermaphrodite, and also male or female flowers. Linnæus's 23d Clafs, *Polygamia.*

Sycamore tree. Common Maple. Ash tree.

ESSAY VII.

On a Cheap and Expeditious Method of Draining Land.

FROM a very extensive experience, I recommend the following method of draining land, as effectual, durable, and cheap.

First make the main drains down the slope or fall of the field. When the land is very wet, or has not much fall, there should, in general, be two of these to a statute acre; for the shorter the narrow drains are, the leſs liable they will be to accidents.

The width of the trench for the main drains should be, at the top, about thirty inches; but the width at the bottom must be regulated by the nature and size of the materials intended to be used. If the drain is to be made of bricks ten inches long, three inches thick, and four inches in breadth, then the bottom of the drain must be twelve inches; but if the common sale bricks are used, then the bottom must be proportionably contracted.

INSERT FOLDOUT HERE

In both cases there must be an interstice of one inch between the bottom brick and the sides of the trench, and the vacuity must be filled up with straw, rushes, or loose mould. For the purpose of making these drains, I order my bricks to be moulded ten inches long, four broad, and three thick. These dimensions make the best drain; and I beg leave to be understood, throughout this efsay, as speaking of bricks formed in the above manner.

The method I pursue in constructing my main drains is as follows:

When the ground is soft and spungy, the bottom of the drain is laid with bricks, placed acrofs. On these, on each side, two bricks are laid flat, one upon the other, forming a drain six inches high and four broad. This is covered with bricks laid flat. *Fig.* 2. *Plate* 2.

When I first engaged in this mode of draining, I conceived that in places where the bottoms of the main drains were firm and solid, as of clay or marl, it would be an unnecefsary expense to pave them with brick.

Under this idea, I recommended them to be constructed as in pl. 2. fig. 3. the sides being formed by placing one brick edgeways, instead of two laid flat. But after the experience of some years, I found that the accefs of air and the alternation of wet and dry, occasioned the hardest clay, or marl, to tumble down, whereby the side bricks, not having a paved bottom, were made to fall in. From the experience of this circumstance, I now direct the main drains to be invariably paved with brick, as represented in pl. 2. fig. 2. This will render them as lasting as the sod, or pipe drains, which I have found free and open after being constructed twenty years. When stones are used instead of bricks, the bottom of the drain should be about eight inches in width. And here it will be proper to remark that, in all cases, the bottom of the main drains must be sunk four inches below the level of the narrow ones, even at the point where the latter fall into them.

The main drains should be kept open till the narrow ones are begun from them, after which they may be finished: but before the earth is returned upon the stones, or bricks, it will be adviseable to throw in straw, rushes, or brush-wood, to increase the freedom of the drain.

The small narrow drains should be cut at the distance of sixteen or eighteen feet from each other, and should fall into the main drain at very acute angles, to prevent any stoppage. At the point where they fall into, and eight or ten inches above it, they should be made firm with brick or stone.

In making the narrow drains I employ four labourers. The first man, with a common spade, takes out the turf, or sods, eighteen inches wide, (the drains being before marked out) and lays them carefully on one side; the second man, with a common spade also, digs out two, three, or more spits of earth (laying it on the other side of the trench) till he has cut through the soil, or staple, and come to the under-stratum of clay, marl, or other hard and solid body of earth. The bottom and sides of this trench must be cleanly wrought; and, allowing for the sloping of the sides in working, should, at the bottom, be clear sixteen inches wide.

In this trench the frame, *Fig.* 5. *Plate* 2. is laid; and, in the middle of it, the third man, who ought to be the strongest and most expert, works the long narrow draining spade in the body of the clay. By taking care to work it at its full depth, he is always sure of his level, if the drains are properly laid out. The wooden frame is of great use; it gives a firm support to the feet of the workman, keeps the bottom of the trench smooth and clean, and serves as a purchase to the wings of the narrow tool. *Fig.* 1, 2, 3, 4, 5. *Plate* 3.

When thirty or forty yards have been cut out by the draining spade, the fourth man cleans the bottom of the drain with the scoop, *Fig.* 6. *Plate* 3. and works it quite smooth; he then covers it with the sods, laying the grafs side downwards. In this part of the work, too much care and attention cannot be used. The sods should be sound and dry, cut even on the sides, and fitted closely to each other. No broken or rotten pieces should be put in; and if any of the sods taken out, in cutting the trench for the narrow drains, are bad, good ones, firm and full of roots of rushes, strong grafs, &c. should be got in the other parts of the field, and their place supplied with the decayed ones. In marshy bad fields, where

INSERT FOLDOUT HERE

[illegible]

[illegible]

[illegible]

sound turf cannot be had, little sticks may be placed acroſs the trench, and the loose and tender sods safely laid upon them. The narrow drains being thus covered, the earth must be thrown in again, taking care that the clay, &c. brought out by the narrow tool, be not mixed with it. No greater length of these drains should be cut than can be finished the same day. The price varies with the depth. For the main drains cut thirty inches above, and thirty-eight deep, laid with bricks, covered, &c. I give about ninepence per rod (eight yards). For the narrow drains, constructed and completely finished according to the foregoing directions, their whole depth (including that of the trench, and that of the draining spade) being thirty-two or thirty-four inches, I give fivepence halfpenny per rod (eight yards*.)

From my much respected friend, the Rev. Mr. Whately, of Nonsuch-Park, in Surry†, I first received an account of the Hertford-

* At this price my labourers, after they were a little acquainted with the work, earned, even in winter, two shillings a day each.

† Profeſsor of Rhetoric in Gresham College.

shire and Efsex method of draining; at the same time he obligingly sent me a set of the tools made use of there, with very particular directions.

The great price of stone and brick in my neighbourhood, rendered the Hertfordshire method too expensive. Hence I took the idea of the sod drains, and the improvement of the tools. Mr. Young, in the second edition of his justly-esteemed *Six Months' Northern Tour*, calls me the inventor of this method of draining. All the merit I claim, is that of having introduced, together with an amendment of their construction, the application of these celebrated tools to a mode of draining with sods or turf, where stone, brick, or even brushwood, is extremely scarce and dear.

Wherever this is the case, I can, from my own experience, recommend the hollow drains covered in the above manner.

I must observe that, in loose crumbly soils, where the wetnefs does not arise from the retention of water by an under-stratum of clay, but from springs, these drains are *improper*: For such lands they should be made of brick or stone. On the contrary, which is most commonly the case, when the wet is prevented from paſsing off by an under-stratum of clay, marl, or a mixture of both, these sod drains are excellent.

For if the whole staple, or soil, is cut through, as it ought to be, the narrow tool will be wholly worked in a solid body, and leave a firm compact ledge, or shoulder, of six inches wide on each side, for the sod to rest on, *Fig.* 4. *Plate* 2. The strength with which the sods are supported, and their depth in the ground, will effectually prevent their removal by any weight on the surface, and secure them from all effects of the weather. Being, at their least depth, twelve inches below the surface, they will also be beyond the reach of the plough.

With respect to the shape of the narrow drains, it will be scarce neceſsary to observe, that their great depth, and contracted width, enable them to draw in the moisture of the earth, and at the same time to keep themselves clear and open.

The tools should be formed of well-wrought iron, and made with great care and exactneſs.

Including the shaft, the narrow tool should weigh 12 lb*.

References to the Plates.

Plate 2. *Fig.* 1. A field with the drains properly laid out. *AAA* the main drains; *a a a a* the narrow sod drains.

Fig. 2. A brick drain.—Proper whether the bottom be hard or soft.

Fig. 3. A brick drain.—Formerly recommended when the bottom was hard, as of clay or marl; but discontinued for reasons already given.

Fig. 4. A narrow drain; *a a* the shoulders for the sod to rest upon; *b* the cut made by the narrow spade. This, and *Fig.* 2 and 3, may be meaſured by the scale of *Plate* 3.

Fig. 5. The wooden frame to be laid in the trench. It is made of two oak-boards, (inch thick) each twelve feet long, and six inches in

---

* These tools are made by Benjamin Royle, smith, in Dolefield, Danesgate, Manchester; and by William Staveley, smith, in Stonegate, York.—Price 12s.

breadth. They are fastened together at the ends by two ribs on the upper side, leaving a slit of five inches for the entrance of the narrow spade. *a* The handle.

Plate 3. *Fig.* 1. A front view of the narrow draining spade. *a* The shaft; *b* the wings for the workman's foot; *c* the iron part of the spade, which is gently concave.

Fig. 2. A side view. *a* The shaft; *b* the wings; *c* two sharp fins, one on each side, for cutting the next spade-graft; *d* the iron part.

Fig. 3. A back view. *a* The shaft; *b* the wings; *c* the cutting fins; *d* the iron part, which is convex.

Fig. 4. A back view in perspective. *a* The shaft; *b* the wings; *c* the fins; *d* the iron part.

Fig. 5. A front view in perspective. *a* The shaft; *b* the wings; *c* the fins; *d* the iron part. It will here be proper to remark, that the perspective views must not be measured by the scale.

Fig 6. The scoop. *a a* The wooden handle; *b* the iron scoop.

ESSAY VIII.

On Top-dreſsings.

IN the middle of March, 1771, I ploughed a rood of land flat; the soil a poor, wet, hungry gravel, with many blue pebbles. Through the year 1770 it was fallowed, receiving five ploughings. On the first of April I marked 17 divisions, each two perches, and manured them with top-dreſsings, and sowed them with Switzerland wheat. The manures, expenses, product, &c. will appear in the following table.

Manure per Acre.	Expense per Acre. l.	s.	d.	Crop per Acre. Q.	B.	P.	G.	Value of Crop. l.	s.	d.	Gain by Manure. l.	s.	d.	Weight per Acre. Cwt.	Value at 3s. per Ct. l.	s.	d.	Gain by Manure. l.	s.	d.
Hens dung, 40 bushels,	1	0	6	2	0	3	1	5	1	3	3	12	11	8½	1	5	6	0	9	0
Wood-ashes, 50 ditto,	1	5	7	1	7	0	0	4	10	0	2	16	8	14½	2	3	6	1	7	0
Coal-ashes, 80 ditto,	1	8	4	1	7	0	0	4	10	0	2	16	8	10	1	10	0	0	13	6
Hens dung, 20 ditto,	0	10	3	1	7	0	0	4	10	0	2	16	8	6½	0	19	6	0	3	0
Coal-ashes, 255 ditto,	4	5	0	1	5	3	0	4	2	6	2	12	2	9½	1	5	6	0	9	0
Ditto, 160 ditto,	2	16	8	1	5	0	1	3	18	9	2	5	5	9¾	1	9	3	0	12	9
Soot, 80 ditto,	3	0	6	1	4	2	0	3	15	0	1	19	8	10	1	10	0	0	13	6
Lime, 80 ditto,	2	0	6	1	3	3	1	3	11	0	1	17	11	8½	1	5	6	0	9	0
Wood ashes, 40 ditto,	1	0	6	1	3	1	0	3	7	6	1	13	2	10½	1	11	6	0	15	0
Soot, 60 ditto,	2	5	5	1	2	0	0	3	0	0	1	4	8	8	1	4	0	0	7	6
Pigeon-dung, 20 ditto	0	15	3	1	1	1	1	2	16	3	0	19	11	6½	0	19	6	0	3	0
Soot, 40 ditto,	1	10	3	1	1	1	1	2	16	3	0	19	11	5¾	0	17	3	0	0	9
Goose-dung, 20 ditto	0	10	3	1	0	0	1	2	8	9	0	10	5	5	0	15	0	—	—	—
Salt, 10 ditto,	3	0	0	0	6	3	1	2	1	3	0	1	11	6	0	18	0	0	1	6
Ditto, 5 ditto,	1	10	0	0	6	2	½	1	19	4	—	—	—	5¾	0	17	3	0	0	9
No manure,	—	—	—	0	6	2	½	1	19	4	—	—	—	5½	0	16	6	—	—	—
Lime, 160 ditto,	4	1	0	—	—	—	—	—	—	—	—	—	—	½	1	5	6	—	—	—

In 1772 the land was clover, and mown once. The sixth column gives the crop in hay; the seventh, the value; and the eighth, the increase by the manures. It would be to little purpose to make any observations upon the above experiment, as the conclusions must be obvious to every person. The poverty of the soil is seen in the crop of corn without manure. The extreme unfavourableneſs of last year to hay crops, was the reason that the clover produced so poorly. The division of 160 bushels of lime, by mistake, was forgot to be sown with wheat.

In March 1773, the rood was ploughed up, and oats were harrowed in. These were reaped the middle of August, and threshed,

	Products.				Per Acre.			
	P.	G.	Q.	P.	Q.	B.	P.	G.
N° 1.	2	0	2	0	5	5	0	0
2.	2	1	1	0	6	4	2	0
3.	2	1	2	0	6	7	0	0
4.	2	0	2	0	5	5	0	0
5.	2	0	2	0	5	5	0	0
6.	0	1	2	0	1	7	0	0
7.	0	2	1	0	2	6	2	0
8.	1	0	2	0	3	1	0	0
9.	1	1	0	0	3	6	0	0
10.	2	0	0	0	5	0	0	0
11.	2	1	2	0	6	7	0	0
12.	2	1	2	0	6	7	0	0
13.	1	0	0	0	2	4	0	0
14.	0	1	2	0	1	7	0	0
15.	0	1	2	0	1	7	0	0
16.	1	1	2	0	4	3	0	0
17.	2	1	0	0	6	2	0	0

Manure.	Expense.			Crop.	Value of Corn.			Gain by Manure.			Gain in thre Years.		
	l.	s.	d.		l.	s.	d.	l.	s.	d.	l.	s.	d.
Coal-ashes, 80 bushels,	1	8	4	55	6	17	6	3	2	6	6	12	8
Hens dung, 20 ditto,	0	10	3	55	6	17	6	3	2	6	6	2	2
Ditto, 40 ditto,	1	0	6	55	6	17	6	3	2	6	7	4	5
Wood-ashes, 50 ditto,	1	0	6	52½	6	11	3	2	16	3	6	19	11
Soot, 80 ditto,	3	0	6	50	6	5	0	2	10	0	5	3	2
Wood-ashes, 40 ditto,	1	0	6	45	5	12	6	1	17	6	4	5	8
Coal-ashes, 160 ditto,	2	16	8	45	5	12	6	1	17	6	4	15	8
Ditto, 255 ditto,	4	5	0	45	5	12	6	1	17	6	4	18	8
Goose-dung, 20 ditto,	0	10	3	40	5	0	0	1	5	0	1	15	8
Soot, 60 ditto,	2	5	5	35	4	7	6	0	12	6	2	4	8
Nothing,	—	—	—	30	3	15	0	—	—	—	—	—	—
Pigeon-dung, 20 ditto,	0	15	3	25	3	2	6	—	—	—	1	2	11
Salt, 10 ditto,	3	0	0	22½	2	16	3	—	—	—	0	3	5
Lime, 80 ditto,	2	0	6	20	2	10	0	—	—	—	2	6	11
Salt, 5 ditto,	1	10	0	15	1	17	6	—	—	—	0	0	9
Lime, 160 ditto,	4	1	0	15	1	17	6	—	—	—	—	—	—
Soot, 40 ditto,	1	10	3	15	1	17	6	—	—	—	1	0	8

Throughout this round of crops, the benefit of the poultry-dung and wood-ashes is very striking. Eighty bushels of coal-ashes also appear in the same light. Upon what principles 160 and 255 bushels of coal-ashes are inferior to 80 bushels, I know not. From a consideration of their qualities, I should have expected no good from them; and several other trials have concurred in confirming me in that idea on poor soils; but in the present one, 80 bushels being so beneficial, will not allow of such a conclusion. Pigeon-dung continuing so indifferent, surprises me very much. The goose-dung being so high in the table, and the 40 bushels of soot so low, are contradictions that I cannot account for. The effect of the lime and salt is pretty much what I should have expected.

GENERAL REMARKS.

Upon looking over the table, I cannot draw one general conclusion. If the nature of the soil be considered, which we have every reason to believe full of the vitriolic acid from its natural sterility, and its abounding with the stone, called, in Hertfordshire, Mother-stone, (a concretion of many small blue pebbles) we should suppose that nothing could be so effectual as the application of alkalies. It is true the wood-ashes are excellent, but why not the lime? and why are coal-ashes in any degree useful, whose quality I take to be much nearer an acid than an alkali? On the contrary, if we set out with a doctrine that has many circumstances to recommend it, viz. that mucilage is the soul of manures, we cannot by any means bring the facts of this experiment to speak the same language. The poultry-dung, it is certain, does wonders, but why not the goose-dung? Why do wood-ashes, in one year, much exceed it, and always nearly equal it? and why do coal-ashes exceed it?—These are circumstances I cannot account for, probably from not being sufficiently acquainted with the component parts of these manures, or the neutral salts which may be formed in the soil by their application. Indeed we ought not to be desirous of founding general conclusions on particular trials, since, in repetitions, several important variations may arise; and the particular trials, on which we rely too much, then turn out mere exceptions, which are lost in drawing more general averages.

ESSAY IX.

On the Scotch Fir.

IN order to raise plantations of the Scotch Fir, let the cones be gathered in the month of February, or March, from thriving young trees, as the old ones are not easily accefsible, nor so productive of seed. These are to be exposed to the heat of the sun, thinly spread on any kind of coarse canvas, taking them under cover in the night-time, and only exposing them when the sun shines. This soon makes the cones expand with a crackling noise. When any quantity of the seed is shed, it must be separated from the cones by a searce, otherwise the first-dropped seeds would become too dry before the cones yielded their whole quantity, which often takes up a considerable time; so that we are sometimes obliged to dry the cones in kilns, to make them give their contents in time for sowing—which ought to be done the end of April or beginning of May. The first method of procuring the seed is certainly the most eligible, though the other answers very well when attentively performed, so as not to damage the seed by too much heat. A light loamy soil, trenched a foot and a half deep, and laid out in beds five feet broad, answers the best for sowing. Let the seeds be sown very thick, and covered with a thick sifting of mould from the alleys. No kind of manure should be given to the beds, as productive of weeds; the drawing of which not only brings up many of the tender plants, but loosens the ground, and makes blanks that let in frosts in winter and drought in summer. To give an idea of the sowing, I never consider my crop of plants good, unlefs they mat like a brush, forming a tough bed that will resist the severest winter. Upon their having two seasons growth, I plant them out irregularly from the seed-bed, about three feet asunder, upon the mountainous grounds where they are to rise to perfection. I begin to plant the driest ground in autumn, eighteen months after sowing, and persist in this operation until the frost prevents me. I begin again in February, or rather as the weather admits, and continue this work sometimes to the end of April, so as to plant out the product of the two-years old seed-beds. I put the plants into the ground with two cuts of a spade, thus >. I raise the point of the angle with what we call a dibble, and laying the plant up to the neck, stamp down the raised sod with the foot. In this method, two men may plant a thousand in a day. When the ground is rocky, or very stony, I use a dibble, shod with iron, having a cleft at the extremity to lead down the root, putting the plants into the ground in the manner that Cabbages are planted. One man will plant as many in this way, as two in the other; yet the first method is preferable, where the ground admits of it, as I have always observed fewer plants to fail. My reason for planting from the seed-bed is, that it comes nearest, to the operation of nature. Plants removed from the seed-bed into the nursery, must have their roots pruned considerably before they can be planted into the pits where they are to continue, which adds greatly to the expense. Besides, *nursing* causes a luxuriant growth in this hardy mountainous tree, which spoils its nature and robs it of longevity.

It is generally believed that there are two kinds of Fir-trees, the produce of Scotland, viz. the red or resinous large tree, of a fine grain, and hard solid wood; the other, a white wooded Fir, with a much smaller proportion of resin in it, of a coarser grain, and of a soft spungy nature; it never comes to such a size, and is more liable to decay. At first appearance this would readly denote two distinct species, but I am convinced that all the trees in Scotland, under the denomination of Scotch Fir, are the same; and that the difference of the quality of the wood, and size of the trees, is entirely owing to circumstances, such as climate, situation, and the soil they grow in. The finest Fir-trees appear in the most mountainous parts of the Highlands of Scotland, in glens, or on sides of hills generally lying to a northerly aspect, and the soil of a hard gravelly consistence, being the natural produce of these places. The winged seeds are scattered in quantities by the wind, from the cones of the adjacent trees, which expand in April and May with the heat of the sun; these seedlings, when young, rise extremely close together, which makes them grow straight, and free from side-branches of any size, to the height of fifty or sixty feet before they acquire the diameter of a foot: Even in this progrefs to height they are very slow, occasioned by the poornefs of the soil, and the numbers on a small surface, which I may say makes them in a constant state of war for their scanty nourishment, the stronger and tallest by degrees overtopping the weaker, and when the winds blow, they lash against one another; this afsists in beating off any horizontal branches that might damage the timber with knots, as well as by degrees crushes the overtopped trees. In such state of hostility they continue struggling until the master-trees acquire some space around them; then they begin to shoot out in a more bushy manner at the top, gradually losing their spiral form, increasing afterwards more in size of body than height; some acquiring four feet diameter, and about sixty feet of height to the branches, fit for the finest deal board. The growth is still extremely slow, as is plainly proved by the smallnefs of the grain of the wood, which appears distinctly in circles from the centre to the bark. Upon cutting a tree over, close at the root, I can venture to point out the exact age, which, in these old Firs, comes to an amazing number of years. I lately pitched upon a tree of two feet and a half diameter, which is near the size of a planted Fir of fifty years of age, and I counted exactly two hundred and fourteen circles or coats, which makes this natural Fir above four times the age of the planted one. Now as to planted Firs; these are raised first in drefsed ground from the seed, where they stand two seasons or more; they are then planted out in the ground they are to continue in, at regular distances; so have a clear circumference round them for extending both roots and branches. The one gives too quick nourishment to the tree which shoots out in luxuriant growth, and the other allows many of the branches to spread horizontally, spoiling the timber with knots; besides, this quick growth, occasions these thick yearly circular coats of wood, which form a coarse grain of a spungy soft nature. The juices never after ripen into a proportional quantity their resinous preservative balm; so that the plantations decay before the wood acquires age, or a valuable size; and the timber, when used in work, has neither strength, beauty, nor duration. I believe the climate has likewise a great share in forming the nature of the best wood, which I account for in the following manner: The most mountainous parts of the Highlands, particularly the northerly hanging situations, where these fine Fir-trees are, have a much shorter time of vegetation than a more southerly exposure, or the lower open countries, being shaded by high hills from the rays of the sun, even at mid-day, for months together;

so that, with regard to other vegetables, nature visibly continues longer in a torpid state there than in other places of the same latitude. This dead state of nature for so long a time yearly, appears to me necefsary to form the strength and health of this particular species of timber. No doubt they may at first show a gratefulnefs for better soil and more sun, by shooting out spontaneously; but if the plant or tree is so altered by this luxury, that it cannot attain any degree of perfection fit for the purposes intended, the attempt certainly proves in vain.

From what is said above, it is not at all my intention to difsuade from *planting* Scotch Fir, but to encourage those that have the proper soil and situation to do so; being of opinion that where these circumstances agree, and there, planting not in lines, but irregularly and thicker than common, the trees will come to be of equal size and value with the *natural* ones. In confidence of this, I have planted several millions on the sides of hills, out of the reach of seed from the natural Firs.

As to the Larch, I have found it to answer extremely well when planted out on barren grounds, from six inches to six feet high; and it is seldom known to fail, except where water has reached its roots. I have often remarked with surprise, that when cattle or deer have broken off the main shoots with their horns, another branch has taken the lead, and stretched away at such a rate as to heal up the wound so completely, that in a few years it was with difficulty I could discover the traces of the injury. The amazing growth of the Larix far exceeds with me (Scotland) all the native as well as foreign trees, bearing the exposure and inclemency of the season better than any of them; and of late I have the pleasure to find that they naturalize themselves by sowing. I wish my experience could afsist me in speaking with as much certainty with regard to the value and usefulnefs of the timber; but in that I can give but little satisfaction, as my oldest trees are not thirty years from the seed.—At Dunkeld I have seen a small summer-house finished with Larix wood; the plants came from London in earthern pots, about the year 1740, rather as a curiosity, than from any expectation of their excellency. Though full of circular knots, the wood looked well, and did not seem to gall or warp so much as Fir of the same age and seasoning would have done. It will be necefsary to remark, that the heart or centre of large trees is generally the knottiest part of the trunk, occasioned by the collateral branches, when young, supporting the stem to stature, which as the tree advances, die and fall off; and this is particularly evident in trees that grow in thickets. The surface soon heals over, and the body of the tree is annually increased by circular rings of wood. I shall suppose a tree to be a foot in diameter when the lower branches die and drop off. In course of time it acquires four feet in diameter, which gives a surrounding coat, one foot and a half in thicknefs, of clean timber, the centre remaining knotty. The growth of the Larix, and manner of dropping its branches when close together, very much resembles the Fir; so I am confident this fault of knottinefs, which seems to be the principal one, will amend by age.

ESSAY X.

On the Physiology of Plants.

DIFFERENT parts of nature have drawn the attention of different philosophers. While some men of the greatest genius have employed themselves in the study of their own species; others have been diligently engaged in investigating the properties of the inferior claſses of animals. Nor are those to be placed in the lowest claſs of philosophers, whose time and attention are engroſsed by that immense portion of nature, the Vegetable Kingdom; though, it is to be regretted that, in general, their observations have been directed more to the external form of plants, than to their internal structure.

The knowledge of the internal structure of vegetables unfolds their economy, and, from a discovery of this, not only botany, but agriculture, might receive great improvement. But this subject is as difficult, as it is important, and, as yet, it is not precisely understood, even by the most curious observers. I am led to engage in it more by the pleasing nature of the study, than the hope of surpaſsing those who have gone before me; and I purpose, in the following Eſsay, to confine myself to a few remarks on the structure, life, and functions, of vegetables.

It is proper to premise, that if the anatomy of plants be not demonstrated throughout, with all the clearneſs that could be wished, this arises from their containing parts of such a degree of minuteneſs, that they elude the human sight. The nature of these must therefore frequently be inferred from analogy only, which is often fallacious. But many things have been ascertained on this subject, and with these I shall begin.

On making a transverse section of a tree, it appears to consist of three distinct parts—the bark—the wood—and the medulla, or pith.

1. The bark consists of two parts—the cuticle, and the true bark. The cuticle of plants affords an external covering to all their parts. It consists of numerous layers, easily separable from each other, and of which the fibres are circular. The true bark may be

considered as a congeries of cellular substance, in which are placed two kinds of organs, the vasa propria, or the veſsels peculiar to the plants, and the longitudinal fibres. Of the use of these, nothing can be said at present.

2. On removing the bark, the wood appears. Its substance is denser than the bark, and its structure more difficult to be demonstrated. But it has been discovered likewise to contain vasa propria, and longitudinal fibres, and, besides these, large veſsels with spiral coats, which run from one end of the tree to the other, and are denominated vasa aëria. Between the wood and the pith lies a green coloured substance, first accurately described by Dr. John Hill, and by him affirmed to contain all the parts of the plant in embryo: he gave it the name of Corona.

3. In the centre of the tree resides the pith, which, in young plants, is very abundant. As they approach to maturity it grows drier, and appears in a smaller quantity; and, in very aged trees, it is entirely obliterated. Its substance is cellular, and, according to the author just mentioned, it is of a similar structure in

all plants. These are the solid parts of vegetables.

But there are likewise fluids, or juices in vegetables; and these are of two kinds. The one is of the same nature in all the variety of vegetables: the other varies according to the different plants in which it exists. The former, which is called the *succus communis*, when collected early in the spring, from an incision made in the birch or vine, differs little from common water. The latter, which is named the *succus proprius*, posfefses various properties in various plants, and gives to each its sensible qualities. These two juices never mingle with each other in the tree, and the latter is found in the *vasa propria* only.

It is not yet ascertained, whether the juices of plants are transmitted through vefsels, or cellular substance. Each side of the question has had its advocates, who have supported their respective opinions with probable arguments: but it is to be regretted, that, on so interesting a subject, no conclusion can be formed from the actual difsection of vegetables. To me it seems most probable, that all the fluids of plants are transmitted through vefsels, for the following reasons. 1. The existence of *vasa propria*, and *vasa aëria*, is discoverable by the naked eye, and made still more manifest by the microscope. That *succus proprius* and air are contained in these is evident; and therefore analogy leads us to believe, that the *succus communis* is also contained in vefsels. 2. Secretion, of which vegetables have undoubtedly the power, is in no instance, that we know of, performed without the action of vefsels. 3. An experiment, made by Dr. Hales, seems clearly to prove, that the sap is contained within its own vefsels, and does not fortuitously pervade every interstice of the plant. He fixed an instrument round the stem of a vine, by which its contractions and expansions could be accurately measured; but he found no difference in the circumference of the trunk, when the tree was full of sap, and when it was entirely without it, although the instrument employed was so nice, as to detect a variation of the hundredth part of a finger's breadth. If the sap had been transmitted, without vefsels, through the cellular substance, this, on the withdrawing of the sap, would have been comprefsed, and of course the stem of the tree would have contracted itself into a smaller compafs.

We are now to consider in what direction the fluids of plants are transmitted.

I. *Of the Course of the* Succus Communis, *or* Sap.

Botanists have made many experiments to ascertain the course of the sap. Early in the spring, when the sap begins to flow, incisions have been made in the trunk and branches of trees, as far as the pith; and, in such cases, it has been constantly found, that a larger quantity of sap flowed from the superior, than from the inferior margin of the incision. This circumstance led to the opinion, that in the beginning of the spring, great quantities of moisture are absorbed by trees from the atmosphere, and hence the source of the abundance of sap *. But this conclusion, I found to disagree with the phenomena of nature from the two following experiments. 1. Having made incisions of various heights into the stem of several plants, I immersed their roots into a decoction of log-wood. The roots absorbed the coloured liquor, which at length began to

* Duhamel and others. See Phys. des Arbres, Tom. I. p. 67.

flow from the superior, and not from the inferior, margins of the incisions; nor had the liquor extended itself much upwards, beyond the margin of the incision from which it was discharged.

2. In the season when the sap flows most abundantly, called the bleeding season, a deep cut was made into the branch of a growing vine, and the greatest quantity of sap was discharged from the upper margin of the incision: but a branch of the same tree, cut in the same manner, being inverted, the sap flowed most copiously from the other margin of the incision, which of course was now that next the root. On the other hand, many experiments may be brought to prove directly, that, in the bleeding season, the sap ascends from the roots towards the branches; the following however may suffice. 1. Early in the spring, when little or no sap had as yet entered the plant, Dr. Hope made a number of incisions, of different altitudes, into the root and stem of a birch. As the sap rose, it first flowed from the superior margin of the lowest incision, and then, in regular succefsion, from the upper margins of the other incisions, till at last, it reached the highest. 2. If, in the beginning

of the bleeding season, before the sap is found in the stem or branches, an incision be made in the root of a vine, a considerable flow of sap will follow the wound. 3. The quantity of sap is very generally proportioned to the humidity of the soil.

II. *Of the course of the* SUCCUS PROPRIUS.

When a portion of the bark and wood of the pine, is cut from the stem, the *succus proprius* flows in considerable quantity both from the upper and under margin of the incision. Hence it occurred to botanists, that this juice might have little or no motion, and that its efflux from such an orifice might depend entirely on its being freed from the presſure of the bark and wood. But I cannot accede to this opionion: for although in the beginning, the *succus proprius* flows from both margins of the incision, in a little while, as I have observed, it is discharged from the superior margin only. This observation in itself is not however decisive. For it may be supposed, that the liquor flows more copiously from the superior margin, because the pressure of the air is leſs upon it, than on the inferior, and because the liquor itself is disposed to fall downwards by its gravity, in the same manner as the *succus communis*. That I might put this matter out of doubt, I placed the branch of a pine in a horizontal position, and another branch I inverted, so that its branches were turned towards the earth. In these situations, I cut a portion of the bark and wood from each, and, in both instances, the *succus proprius* flowed only from those margins of the incisions which were farthest from the roots. Hence it appears clearly, that the course of this juice, in its vefsels, is never from the roots towards the branches, but always in the contrary direction.

Besides the vefsels of the *succus proprius*, and those conveying the sap, a third kind are found in vegetables, named air-vefsels, or *vasa aëria*. These are chiefly situated in the wood, leaves, and petals; but are wanting in the bark of trees, and in the herbaceous plants. They are formed by a number of small filaments, spirally rolled up, so as to form a cavity in the middle. The name of *vasa aëria* has been given them, because they are empty of liquor, and because a great quantity of air is certainly found in the wood of plants, where these vefsels are chiefly placed, and where there is no peculiar organization. They are supposed to be the instruments of respiration in vegetables; but in what manner this function is performed, is not clearly understood.

I. Some imagine that the air enters the plants by the roots, in a non-elastic state, and gradually recovers its elasticity in its pafsage through them. To this opinion it is objected. 1. That a great number of *vasa aëria* is found in the roots of trees, where the juice has undergone little or no circulation, and where of course little or no air can be supposed to be evolved. 2. That the roots are very incommodiously placed for absorbing air, being generally so deeply buried in the earth, as to be entirely out of its reach.

II. Others suppose the air is absorbed by the leaves, and thence carried into the body of the plant. There are, indeed, many airvefsels in the leaves, and these seem necefsary for receiving the air evolved by circulation, which at length pafses off with the perspirable matter. But if the air were absorbed by the leaves, and descended towards the roots, its motion would be opposite to that of the sap, and, instead of afsisting, would obstruct its progrefs. It is commonly believed, that after the air has entered vegetables, it is expanded or contracted, according to the variations of the temperature of the atmosphere, and in this way afsists the ascent or descent of the fluids. To this opinion it may be objected. 1st, That the air-vefsels in the roots, where the sap is first put in motion, are so deep-seated, that the changes in the heat of the atmosphere cannot effect their temperature. 2. That the common juice ascends, and the proper juice descends, whether the air be hot or cold. 3. That the prefsure of the air-vefsels on those which contain juice, will not more promote than obstruct the motion of the fluids in a given direction, unlefs the vefsels which include them contained valves, and in this case these fluids could not have a retrograde motion. Let us look for some more probable opinion.

Dr. Hill has demonstrated, that the cuticle of plants is an organized substance, containing vefsels. In trees and shrubs, these vefsels have an external opening; but in the herbaceous plants this is wanting. Trees and shrubs only are pofsefsed of *vasa aëria*, and, when a plant is placed under the exhausted receiver of an air-pump, the air enters through the cuticle, and only ifsues from the wood, in which the *vasa aëria* are situated. From these circumstances taken together, and considered attentively, we have reason to conclude, that the air's proper entrance to the *vasa aëria* is through these cuticular vefsels. Thus, in the early part of the spring, the gentle heat expands the mouths of these vefsels, before contracted by the winter's cold. Into these orifices, the external air rushes and prefses down to the roots. To these it gives energy, as it does to the moving fibres of animals; and, by its prefsure, it may afsist in propelling the juices upwards. An additional quantity of air is evolved by the internal motions of the plant, and the whole pafses off with the perspirable matter. In this way there seems to be a circulation of air through plants, afsisting and afsisted by the powers which move the juices.

The two following facts confirm the above opinion, and, at the same time, show, that in plants, as well as animals, impeded respiration impedes the motion of the fluids, and interrupted respiration destroys it.

1. In the winter season, I covered several young trees with varnish, and at the same time wrapt them in wax-cloth, leaving the tops of the branches only exposed to the air. They remained in this situation during the following summer, when some of them lived, though in a languid state, and put out a few leaves; but those from which the air had been more accurately excluded, died without a single exception. 2. Trees over-grown with mofs have few leaves, weak shoots, and no fruit. The practice of gardeners is therefore to be commended, who, in the spring, strip the mofs from the bark of aged trees, and thus admitting the accefsion of the air, restore them to verdure and fruitfulnefs.

Having considered the course of the fluids in vegetables, we next proceed to examine the powers by which these fluids are moved.

Capillary attraction has generally been accounted the cause of the motion of the juices of plants; and the permanence of the action of this power has been supposed to depend on the evaporation from the leaves. Of late years, indeed, botanists have ascribed to plants a vital power, which they believe afsists the flow of the juices; and to this opinion I accede, for the following reasons. 1. The descent of the juices, that is, their return from the branches to the roots, cannot be explained without the supposition of a vital power regulating the motion. A flow of fluids, through capillary tubes, will only take place, when the resistance, at the one end, is diminished. This might account for the rising of the sap, when warmth is applied to the leaves, but cannot account for its descending in the same circumstances, that is, when the atmosphere is warmer than the earth. But this takes place constantly, with respect to the *succus proprius*, and it is probable, that part of the sap has the same course, both in the day and night. 2. The exertions of many plants, on the application of stimuli, afford another argument in support of their muscular power, and the spontaneous motions of other plants confirm the same opinion. 3. Light, admitted to plants, increases their perspiration, and causes a leaf, before inverted, to resume its natural position *. The influence of darkneſs

* Miller in the Philosophical Transactions, and Bonnet, Sur l'usage des Feuilles.

contrasts these effects, and it produces, what is called, sleep in plants, although the heat of the atmosphere be not diminished. These facts seem to prove the irritability, or muscular power of vegetables. 4. If the fluids of plants are conveyed through vefsels, as I have already rendered it probable they are, can we suppose these tubes to be of so small a diameter, as, by capillary attraction alone, to raise the juices from the roots to the summits of the loftiest trees? 5. On the supposition of the fluids being moved entirely by capillary attraction, how happens it, that the sap of the vine flows from an incision made in the spring, and not from one made in summer? In this case, as the vefsels remain the same, and the heat is at least not diminished, the efflux of sap ought to be equally copious in summer as in spring. 6. Capillary tubes, filled with liquor, do not discharge their contents when broken acrofs. But from the stem of a vine, cut transversely, a large quantity of fluids is discharged, as has been demonstrated by Dr. Hales. 7. The analogy between vegetables and animals, which was formerly pointed out, gives a reasonable presumption, that the fluids of both are moved by similar powers. In animals, the powers of circulation are respiration and muscular action: of those powers in plants we have already treated, and what has been said on the subject, seems to show, that the motion of the juices in plants is rather to be ascribed to them, than to capillary attraction.

I might draw some arguments, in addition to these, from some experiments I have lately made, to ascertain the effects of air impregnated with various effluvia, of light, and of saline solutions, on the growth and qualities of vegetables; but these, being as yet incomplete, I forbear to detail. In general, however, it appeared, that there are particular substances which increase the growth of plants, by acting as stimuli on their moving fibres.

There are some other functions which belong to vegetables, of which I shall now endeavour to give some account.

Plants, as well as animals, perspire, and in both cases, this function is efsential to health. By the experiments of Dr. Hales *, and M. Guettard †, it appears, that the perspirable

* Statical Efsays, vol. I. p. 49.

† Mem. de l'Academie des Sciences, 1748.

matter of vegetables differs in no respect from pure water, excepting that it becomes rather sooner putrid. The quantity perspired varies, according to the extent of the surface from which it is emitted, the temperature of the air, the time of the day, and the humidity of the atmosphere. As the leaves form the greatest part of the surface, it is natural to suppose, that the quantity of these will very materially affect the quantity of the perspiration. Accordingly, the experiments of Dr. Hales have ascertained, that the perspiration of vegetables is increased or diminished, chiefly, in proportion to the increase or diminution of their foliage *. The degree of heat in which the plant was kept, according to the same author, varied the quantity of matter perspired; this being greater, in proportion to the greater heat of the surrounding atmosphere. The degree of light has likewise considerable influence in this respect: for Mr. Philip Miller's experiments prove, that plants uniformly perspire most in the forenoon, though the temperature of the air, in which they are placed, should be unvaried. Mr. Guettard likewise

* Statical Efsays, vol. I. p. 29.

informs us, that a plant, exposed to the rays of the sun, has its perspiration increased to a much greater degree, than if it had been exposed to the same heat, under the shade. Finally, the perspiration of vegetables is increased in proportion as the atmosphere is dry, or in other words, diminished in proportion as the atmosphere is humid.

The more vigorous and healthy the plant, the more copious the perspiration; this function, like the rest, depending much on the vital energy. Excefsive perspiration seems to hurt, and even sometimes to destroy vegetables; defective perspiration is equally injurious. It is also found, that this function is performed chiefly, if not altogether, by the leaves and young shoots. That it may be properly carried on, all leaves are deciduous; in those trees, called ever-greens, there is a constant succefsion of leaves, to prevent the organ of perspiration from becoming rigid.

Dr. Hales first observed, that a quantity of moisture is absorbed by plants, when exposed to a humid atmosphere. This absorption, as well as the prespiration, is performed by the leaves; but in what manner has not yet been ascertained. Experiments made by M. Guettard * show that perspiration is more considerable from the upper, than from the under, surface of leaves, and those of the same author, of Duhamel †, and Bonnet ‡; demonstrate, that absorption, on the contrary, is much greater at the inferior surface than at the superior. To prove this, the superior surface of one leaf, and the inferior surface of another, were covered with varnish, and the consequence was, that the former, in a given time, suffered little diminution of weight, but the latter became much lighter. Again, similar leaves were laid upon a surface of water, and it followed, that those which had their superior surface inverted, gained little weight, and for the most part died in a few days; while such as had their inferior surface applied to the water, became much heavier, and flourished many months. These facts make it evident, that perspiration, and absorption, are not performed by the same veſsels, but that each has its peculiar organs.

* Memoires de l'Acad. des Sciences, 1749.

† Phys. des Arbres, tom. I. p. 153.

‡ Traité des Feuilles, Mem. I.

It has been commonly supposed, that perspiration takes place, chiefly, when the air is warm; and absorption, on the other hand, when it is cold and moist. But unlefs the vefsels, peculiar to absorption, which are placed in the under surface of the leaves, were kept constantly in action, they would necefsarily collapse or decay. All absorbing organs have a peculiar structure, and an action depending on life: that such an organization is present in the leaves of plants, it is reasonable to conclude, because dried leaves do not absorb. The same reasoning is applicable to the absorption performed by the roots: for when a small portion of the root of a hyacinth, growing in water, is cut off, the whole root dies, and new roots are shot out, having their extremities peculiarly adapted to the absorption of nourishment.

The noxious matter, carried off by perspiration, requires large dilution to prevent its hurting the delicate structure of the leaves, and in this state accordingly it is thrown out on their surface. Here the noxious part is excreted, but part of the diluting fluid is reabsorbed, to serve the purpose of secretion, which could not be performed, unlefs the common juice, or sap, were previously prepared. In the same manner, in the animal body, the saline and putrid matter, carried off by the urine, must be liberally diluted, to prevent it from injuring the tender structure of the kidneys; yet, when it is safely lodged in the bladder, a part is reabsorbed, and the grofser excrementitious matter is alone thrown out. Something of the same kind happens in the perspiration of animals. They certainly take in something useful from the surface of their bodies, and this is probably performed by vefsels opening outwards, different from the common exhalents. The great quantity of water, absorbed during the use of the pediluvium, and that singular symptom in diabetes, of the patient's voiding a much greater quantity of urine, than there is liquor taken in by the mouth, seem to confirm this afsertion.

Neither in plants, nor in animals, can we measure the exact quantity perspired or absorbed: we can only ascertain the excefs of the one over the other. For example, if a heliotropium, or sun-flower, in one day lose twenty ounces of its weight, in another lose nothing, and in a third gain in weight ten ounces, it is only thence to be concluded, that sometimes the quantity perspired exceeds, sometimes it equals, and sometimes it is lefs than the quantity absorbed.

Plants are pofsefsed of a power of forming their different parts, and this is done by secretion. We may conjecture what the agents are which produce this effect, but in respect to the manner of their operation, we are entirely in the dark. In animals, where the vital power is strong, this is the principal agent in producing the new arrangement of parts, which is made in every secretion; but in plants, where this power is weaker, it would be unequal to perform the function, if it were not afsisted by absorption and fermentation. Wherever any firm matter is to be secreted, the vefsels have a convoluted course, to allow the juice to be fermented, and the thinner parts to be absorbed. In this manner, the stones and kernels of fruits are supplied with nourishment by fibres, which are much convoluted. The proper juice seems to be formed only when the sap has ascended towards the leaves, and is descending to the roots. The wood also is formed during the descent of the sap; for when a ligature is made round the stem of a tree, the wood above the ligature becomes much thicker, while that below remains of its former size.

The pabula, from which vegetables receive the matter of secretion, are contained in the surrounding elements. They are chiefly nourished by the water they draw from the soil; but somewhat they likewise derive from the light of the sun, on which their sensible qualities principally depend. On this subject I have likewise made some experiments, but not with that degree of exactneſs, which should enable me to lay them before the public.

Some botanists have conceived, that plants, as well as animals, have a regular circulation of their fluids. Others think this very improbable. On both sides, recourse has been had to experiments; and from these, conclusions perfectly opposite have been deduced. When a ligature has been fixed round a tree, in such a manner, that no juice could be transmitted through the bark, the tree has been found to thicken above the ligature; but below it, to continue of the same circumference. Hence some have concluded, that the sap ascends through the wood, and descends through the bark. Those who are of a contrary opinion have found, that, in certain cases, the juice ascends through the bark only: for when a portion of the wood has been cut out, and the bark exactly replaced, the growth of the tree has been found to go on unchanged: hence it is said, that the juice is transmitted equally through all parts of vegetables. The experiments adduced on each side of the question are just, but the reasonings on these, by each party, seem equally inconclusive. The analogy of animal nature appears to favour the opinion, that the juice rises through the wood only, and descends only through the bark; but this analogy is not complete throughout. The arteries are not placed in the internal parts alone, nor the veins in the external, but they accompany each other through every part of their distribution. In vegetables, the sap rises *from* the roots, but the proper juice descends *towards* them; in the descent of the juice, the wood acquires its growth, and absorption is a constant action of the leaves. These observations render it probable, that there is a circulation of the juices; and if there be, the vefsels which perform it, we may reasonably believe, accompany each other through every part of their course.

On the whole we may conclude, that the formation and growth of the parts of plants, depend, chiefly, on the vital energy, which is not however exerted, except on the application of stimuli. We admire the marks of wisdom and design, which appear in the creation and preservation of vegetables, but we have no reason to believe that they are pofsefsed of any intelligent power, which presides over and directs their peculiar functions.

Both plants and animals are, from their construction, much under the influence of stimuli, and all organized beings are regulated more by general, than particular, laws.

The principle of life seems universally diffused through nature, but bestowed on different beings in different degrees. To animals is given the largest share; but throughout the whole animal kingdom, one species descends below another in the perfection of its mental powers, as well as of its organic sensations. And this progrefsion is so very gradual, that the most perfect, of an inferior species, approaches very near to the most imperfect, of that which is above it. The chain is continued between vegetables and animals. Both have the power of propagating their species, and their modes of procreation are similar. In the lower claſses of animals, the powers of sense and motion are very indistinct. The coral and the water polypus adhere to rocks, as plants to the earth; and, like these, die on being severed from the place where they grew. There are likewise plants, which in many things resemble animals. The Burrhum Chundalli, lately brought from the East Indies, poſseſses a living principle, which discovers itself in the spontaneous, and almost constant motion of its leaves. The *Sensitiva Mimosa*, and *Muscipula Dionæa*, show wonderful activity on the slightest impreſsions, and take the flies and other insects prisoners, by the contraction of their leaves. That these plants *live*, will be granted; but I suspect that they likewise *feel*. I doubt whether we are right, in confining the capacity of pleasure and pain to the animal kingdom. This I may affirm, that some circumstances, common to the generation of plants and animals, and many similarities in their functions and structure, would lead us to the opinion, that sensation likewise is bestowed on both. It is vain to attempt to establish absolute rules, by which plants may be distinguished from animals, in every case whatsoever. There are animals, which grow to a spot, and, like plants, are nourished by the pores of the skin. And there are plants, which surpaſs some animals in vital power, and, perhaps, in sensation.

Wherever the principle of life exists, there is a peculiar organization; and as much mechanism is neceſsary to the structure of a vegetable, as of a human being. This view of the life of vegetables, raises botany to the rank of philosophy: it adds fresh beauty to the parterre, and gives new dignity to the forest.

END OF THE FIRST VOLUME.

Printed at the Office of
T. WILSON and R. SPENCE,
High-Ouſegate, York.

CONTENTS

OF VOLUME FIRST.

BOOK I.

PAGE

The Rise and Progreſs of Agriculture, . 11

ESSAY I. By A. Hunter, M. D.

On the Nourishment of Vegetables, ... 17

ESSAY II. By A. Hunter, M. D.

On a Rich and Cheap Compost, . . . 38

ESSAY III. By A. Hunter, M. D.

On Vegetation, and the Analogy between Plants and Animals, with a Plate, . . . 49

ESSAY IV. By A. Hunter, M. D.

On Steeps, ... 59

ESSAY V. By A. Hunter, M. D.

On the Roots of Wheat, with a Plate, . . 65

ESSAY VI. By A. Hunter, M. D.

On Vegetation, and the Motion of the Sap, . 70

ESSAY VII. By A. Hunter, M. D.

On a New Method of Cultivating Weak Arable Lands, ... 102

ESSAY VIII. By John Harrison, Esq.

On the Robinia, or False Acacia; commonly called the Locust Tree, ... 110

PAGE

ESSAY IX. By T. Haliday, Esq.
On a new Species of Grain, called Siberian, or Haliday Barley, ... 120

ESSAY X. By A. Hunter, M. D.
On Potatoes, ... 127

ESSAY XI. By A. Hunter, M. D.
On the Culture of Turnips, ... 135

ESSAY XII. By J. S. Morrit, Esq.
On the Culture of Carrots, and their Use in Fattening of Hogs, ... 141

ESSAY XIII. By A. Hunter, M. D.
On the Study of Nature, ... 149

ESSAY XIV. By A. Hunter, M. D.
On the Time of Sowing, ... 152

ESSAY XV. By John Grieve, M. D.
On a Wine, called by the Tartars Koumiſs, . 193

ESSAY XVI. By the Rev. Robert Peirson.
On the Connection between Botany and Agriculture, ... 215

ESSAY XVII. By J. Ainslie, M. D.
On the Nature and Properties of Marl, . . 224

ESSAY XVIII. By a Gentleman who wishes to be unknown. The latter Part and Plan, by A. Hunter, M. D.
On Agriculture and Manufactures, ... 269

ESSAY XIX. By R. Townley, Esq.
On Goose Dung, ... 278

PAGE

ESSAY XX. By Sir J. Methuen Poore, Bart.
On the Advantages of Raising Potatoes on Fallows, ... 285

ESSAY XXI. By A. Hunter, M. D.
On Drill-Sowing, ... 288

ESSAY XXII. By the Rev. Mr. Dickson.
On Manures, and their Operation, ... 299

ESSAY XXIII. By C. Baldwin, Esq.
On Oil used as a Manure, ... 317

ESSAY XXIV. By A. Hunter, M. D.
On Top-Dreſsings, ... 324

BOOK II.

ESSAY I. By Thomas Percival, M. D.
On the different Quantities of Rain which fall at different Heights over the same Spot of Ground, ... 329

ESSAY II. By R. Townley, Esq.
On the Culture of Potatoes, ... 344

ESSAY III. By the Rev. Robert Peirson.
On the Analogy between Plants and Animals, 361

ESSAY IV. By A. Hunter, M. D.
On Experiments, ... 366

EXPER. I.
On the Oil-Compost, ... 366

EXPER. II.
On Manuring Meadow Lands, ... 371

PAGE

Exper. III.

On a New kind of Manure, ... 373

Exper. IV.

On the Oil-Compost, ... 376

Exper. V.

On Siberian Spring Wheat, ... 378

Exper. VI.

On the Howard, or large Bedfordshire Potatoe, 378

Exper. VII.

On the Increase of Potatoes, ... 380

Exper. VIII.

On the Increase of Potatoes, ... 380

Exper. IX.

On the Oil-Compost, ... 381

Exper. X.

On the Oil-Compost, ... 382

Exper. XI.

To make a rich Compost of Pond-mud, &c. . 385

Exper. XII.

On Protecting Wall Fruit, ... 387

Exper. XIII.

How to Improve the Turf of poor Pasture Lands, 388

Exper. XIV.

How to Renovate an old Mulberry Tree, . . 390

Exper. XV.

A general Idea of the Oil-Compost, . . . 391

PAGE

EXPER. XVI.

A profitable Method of Sowing Wheat on Land too strong for Turnips, ... 394

EXPER. XVII.

On Siberian Spring Wheat, ... 396

EXPER. XVIII.

On the Method of raising Seedling Potatoes, . 398

EXPER. XIX.

On the Alternate Husbandry, ... 401

EXPER. XX.

The Dimensions of an Earthen Fence, as made in Northumberland, ... 404

EXPER. XXI.

A Method of Preparing a rich Compost, . . 405

EXPER. XXII.

A Comparative View of the three different Methods of Sowing Barley, ... 407

EXPER. XXIII.

On the Oil-Compost, ... 411

EXPER. XXIV.

On the Juice of Carrots, &c. 412

EXPER. XXV.

On a Method of raising Potatoes in Winter, . 423

EXPER. XXVI.

On Sowing Turnips for late Feeding, . . 423

EXPER. XXVII.

On Feeding Sheep, and a Substitute for Folding, 424

PAGE

EXPER. XXVIII.

A Comparative View of two crops of Barley, the one Drilled, and the other sown Broadcast, 426

EXPER. XXIX.

On Malt-Dust as a Manure, ... 427

EXPER. XXX.

On the number of Grains contained in a Bushel of Wheat, and other Seeds, ... 427

EXPER. XXXI.

A Method of making excellent Butter from the Milk of Cows fed upon Turnips, . . 429

EXPER. XXXII.

A new and profitable Method of raising a crop of Turnips in Drill, ... 430

EXPER. XXXIII.

On the Quantity of Ashes to be obtained by Burn-baking, ... 435

EXPER. XXXIV.

On Spring Wheat, ... 435

EXPER. XXXV.

On Sowing Carrot-Seed, ... 436

EXPER. XXXVI.

The Method of making Whale-Compost, . . 437

EXPER. XXXVII.

On the Oil-Compost, ... 439

PAGE

EXPER. XXXVIII.

A Comparative View of Baron Van Haake's Compost, the Oil-Compost, and Soot mixed with Ashes, ... 441

EXPER. XXXIX.

On Egyptian Wheat, ... 442

EXPER. XL.

On the Culture of Cabbages, ... 444

EXPER. XLI.

The Method of using Sea-Weed in Scotland, . 447

EXPER. XLII.

The Method of preparing Land for sowing Lucern broad-cast, ... 449

EXPER. XLIII.

On Transplanting Potatoe Tops, . . . 452

EXPER. XLIV.

On Nutritive Lime, ... 454

EXPER. XLV.

On feeding Hogs with Potatoes, . . . 455

EXPER. XLVI.

A Comparison between Red and White Wheat, . 456

EXPER. XLVII.

On the best Method of raising Early Potatoes, 457

EXPER. XLVIII.

On Lime, ... 460

EXPER. XLIX.

On preparing Seed Wheat with Oil, ... 464

PAGE

EXPER. L.

On Dibbling Wheat, ... 467

EXPER. LI.

On Claying Land, ... 469

EXPER. LII.

On Siberian Barley, ... 470

EXPER. LIII.

A Comparative Review of Manures, . . . 470

EXPER. LIV.

On Potatoes, ... 472

EXPER. LV.

On Fattening Hogs, ... 472

ESSAY V. By the Rev. John Buxton.

On the most Profitable Method of Managing Light Arable Lands, ... 475

ESSAY VI. By the Rev. Robert Peirson.

On the Sexes of Plants, ... 480

ESSAY VII. By T. B. Bayley, Esq. F. R. S. & S. A.

On a Cheap and Expeditious Method of Draining Land, with two Plates, . . . 492

ESSAY VIII. By Arthur Young, Esq.

On Top-Dressings, ... 502

ESSAY IX By James Farquarson, Esq.

On the Scotch Fir, ... 508

ESSAY X. By George Bell, M. D.

On the Physiology of Plants, ... 517