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TWO LECTURES

ON

AGRICULTURAL CHEMISTRY,

BY

HENRY YOULE HIND,

MATHEMATICAL MASTER, AND LECTURER IN CHEMISTRY AND NATURAL PHILOSOPHY, AT THE NORMAL SCHOOL FOR UPPER CANADA.

PRICE 1s. 3d.

TORONTO:

HUGH SCOBIE, ADELAIDE BUILDINGS, KING STREET.

1850.

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Compliments

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PREFACE.

The following pages contain the substance of lectures on Agricultural Chemistry, delivered during the past summer at the preliminary meetings for the formation of Teachers' Institutes, in various County towns of Upper Canada. In preparing them for the press, the special object of general utility has been prominently kept in view. The lecturer has endeavoured to present in a brief and familiar manner, the chief points in a system of Agricultural Chemistry, confining himself as much as possible to the statement and elucidation of useful principles and facts.

To the lectures there will be found appended, the mode of practising a few interesting and simple experiments, illustrative of the circumstances connected with the food and growth of vegetables.

These lectures are now addressed in their present form to the Farmers and Schoolmasters of Upper Canada, with a hope that they may assist in calling forth a spirit of judicious enquiry, among the many intelligent and enterprising members of those numerous bodies.

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LECTURES

ON

AGRICULTURAL CHEMISTRY.

LECTURE I.

Introduction—Object of Agricultural Chemistry—Conditions of Vegetable life and health—Atmospheric food of Vegetables—Carbonic Acid—Water—Ammonia—Proportion in which substances originally obtained from the atmosphere exist in vegetables—Solid food, its entrance into vegetables—The Soil—Mineral ingredients necessary to vegetable life—Sulphur—Phosphorus—Potash — Soda — Magnesia—Lime—Flint—Iron Chlorine—Iodine—Division of Vegetables into Potash, Flint, and Lime Plants—Analysis of a soil from Chambly, L. C.—Ploughing, Draining, Fallowing—Rotation of Crops—Manures—Farm-yard Manure—Urine Gypsum—Lime—Wood Ashes—Good husbandry—Ratio of grain crops to green crops—View of this ratio in the County of York and Upper Canada.

We rarely appreciate the value of any science in its state of infancy. It is generally impossible to foresee what useful results may flow from its practical application. When any new discovery is brought to bear with advantage upon industrial labour, it soon acquires a popular interest which ensures its rapid spread; electricity itself had created no stir in the arena of practical life, until electro-plating and the telegraph gave it importance in the eyes of practical men; and now we know what it has done, our anticipations are almost boundless of what it may be made to do—many of us, looking with confidence to a day, not far distant, when some new discovery will convert it into a source of cheap and commodious motive power.

The science of chemistry has for ages been the handmaid of the manufacturer in the preparation of raw materials for useful and refined purposes. It is only lately that her aid has been sought by the producer; and with such successful results, that the light which the application of chemistry to agriculture has thrown upon his operations, enables him to convert an experimental art into an intellectual and noble science.

A branch of knowledge, hardly a dozen years old in its practical application, can scarcely be supposed to have met with an extended appreciation among the farming communities of Canada, or even to have received the attention of those whose time and opportunities afford them facilities for improving their acquaintance with it.

In its early stage of development the science of Agricultural Chemistry was necessarily very imperfect, and often much misunderstood. A too sanguine expectation of the magnitude of its promised results, while still in this imperfect state, led to much disappointment, which had the effect of creating a violent prejudice in the minds of many practical men,—neither was it until materials drawn from experiments confirming, or modifying the prognostications of theory, were moulded into a rational system of Agriculture, that the visionary hopes of multitudes became sobered down into a proper view of the actual good to be obtained,—an event which has taken place during the last 4 or 5 years. What Chemistry has already done for Agriculture is immense: what she may yet do is incalculable. And now that a clear insight into the relationship is established, the difficulty of presenting a popular view of the subject has almost vanished.

Very strong prejudices exist among farmers against book farming, prejudices which have arisen from disappointed hopes, and ruinous loss in following arbitrary rules. Agricultural science is no system of book-farming—it presents no prescribed rules to be implicitly obeyed. It portrays in simple language, devoid of technicalities, the *reasons* why farmers plough, drain, fallow and rotate their crops; it shows how repeated cropping without the application of manure must inevitably ruin for a time the most fertile soil; and it establishes such an intimate relationship between the soil and the kind of vegetable growing upon it, that every farmer may frame for himself a rational system of husbandry, as varied as the soil he may chance to cultivate. It has been occasionally urged by some, who speak from experience acquired in a very contracted sphere, that Canadian farmers in possession of a fertile soil, do not require the aid of a scientific system of agriculture. Such an objection, rarely advanced, it is true, may be dismissed by a reference to the present deteriorated condition of many fertile regions, and to that growing desire which every intelligent farmer exhibits to make himself acquainted with the rationale of agricultural processes—as well as to the invariable success attending the acquirement of such information. Another objection to its general diffusion is said to be found in the circumstances by which Canadian farmers are frequently surrounded—distance from markets, the high price of labour, the low price of produce and of land, all conducing to foster a system of husbandry directly opposed to rational views. Agricultural science is replete with suggestions, many of which may be received, and many, if not found remunerative, rejected; it moulds itself to every condition of locality and circumstance, and wherever calculation proves that some of its suggestions are not remunerative, they can form no part of a rational system for that neighbourhood. The complaint of diminishing scales of produce is general throughout the older settled portions of the Province; it has been long and loudly urged in New England and the State of New York History furnishes us with numberless examples of once famed fertile soils—now scarcely able to make a quadruple return.

["The state of agriculture in the northern part of America, in our own provinces, and in New England, is generally what the state of agriculture in Scotland probably was 80 or 90 years ago. In some parts of New Brunswick they are very nearly in the precise condition in which Scotland was 120 years ago. Go as far west as you like, and as far south as you like, the same general description applies to the whole."—Professor Johnston.]

Enquiries into the causes of these results inform us that they are the natural consequences of the system of farming pursued. Where little attention is paid to a judicious rotation of crops, to surface draining, to manuring, to the destruction of weeds and the selection of seed,—in a word to as careful a management as circumstances will permit of all farming operations,—can we be surprised that the average of Canada's staple product, wheat, is *less than one-half* the average of England and many parts of continental Europe.

The local experience of every farmer in the country will afford him abundant illustration of the vast difference in the results produced by good and bad farming. There is not an old settled Township in the Province, which does not furnish many instances of intelligent and well-informed men, annually reaping double, and sometimes treble the average amount of produce from their farms, their neighbours are vainly endeavouring to obtain. These successful results do not necessarily flow from the accidental possession of more fertile soils, but rather from careful industry regulated by experience and well applied information. But agricultural information obtained by experience alone, is limited in its application; its value becomes materially lessened when the circumstances under which it was acquired are changed. A farmer who succeeds well by dint of long practice, upon a clay soil, is at fault when the scene of his operations is changed to one of a sandy nature.

Agricultural Chemistry by descending to elementary principles, enables a farmer to build up a system of husbandry adapted to every kind of soil, and every variety of climate in which cultivated crops are capable of being produced with advantage.

The object of Agricultural Chemistry is to trace the connection which exists—

1st. Between vegetables and the air and soil in which they grow.

2nd. Between vegetables and animals.

Since there is not the slightest ground for the supposition that vegetables or animals create matter, every portion of their structure being derived from air and soil, it is manifestly of great importance to know the nature of those substances which serve the purposes of food. We can only obtain this information, by endeavouring to ascertain what simple substances* are common to air, soils, vegetables and animals; and to trace, as far as the present state of the science enables us, in what way this mutual interchange of substances takes place. It is almost needless to remark, that we must not expect to find any simple substance in a vegetable or in an animal which does not exist in air or in the soil.

A very superficial examination of the circumstances under which vegetables grow, furnishes us with the conditions upon which their life and health are dependent.

These are five in number.

1st. The presence of air.

2nd. The composition of the soil.

3rd. The moisture of the soil.

4th. The moisture of the atmosphere.

5th. The temperature of air and soil.

Air.—Pure country air is composed of two invisible gases, in which a small amount of vapour of water is always dissolved, together with a minute quantity of a sour tasted gas, called carbonic acid or choke damp. In 100 gallons of air we find,

79 gallons of Nitrogen.
20 do. do. Oxygen.
$\frac{1}{3}$ pint of Carbonic Acid.
$\frac{2}{3}$ do. do. dissolved Water, on a cool summer's evening.

These gases are intimately mixed together, and always in the same; or very nearly the same proportions, and this is the case whether air is taken at the level of the sea or from the top of high mountains.

[Nitrogen is a kind of simple air or gas, it is tasteless, invisible, extinguishes flame, and is poisonous to animals in its

*(Note 1.)

pure state. It serves to weaken the powerful effect of oxygen, with which it is mixed in the air we breathe.* Oxygen is a simple gas, possessing many extraordinary properties. It is destitute of smell and colourless; all bodies burn with increased brilliancy in oxygen, and animals when they breathe it pure, are thrown into a state of the greatest excitement or fever, terminating in death. It forms a rust when it combines with metals, as with iron &c. It constitutes eight-ninths of water by weight, and is found to form a large portion of all rocks stones &c.† Water in the form of invisible vapour is always found in air, the quantity depends upon the temperature, and varies from ½ to 1½ per cent., that is, in 100 gallons of air there will be from half a gallon to one gallon and half of watery vapour, (nearly equal to a fourth part of a cubic inch of water,) according to the warmth of the air. The deposition of dew is dependent upon the properties of air and plants acting simultaneously. When the sun sets the leaves of vegetables on cloudless nights rapidly become cool, and chill the air about them, causing it to deposit upon the upper surfaces of the leaves, the moisture which, in its chilled state, it cannot retain.]

The air extends to the height of about 45 miles, and presses upon the surface of the earth with a weight equal to nearly 15 lbs. to every square inch of surface; it is, nevertheless, 814 times lighter than water. During thunder storms the passage of lightning through air, causes the formation of a substance, named Ammonia‡—a gas of very pungent odour, easily dissolved in water, and familiarly known by the name of Spirit of Hartshorn. Rain water invariably contains ammonia, which it collects from air in its descent to the earth.

Air, upon which the life of all vegetables is dependent, contains, as we have seen, insignificant quantities of three bodies, Carbonic Acid, Water and Ammonia.

One of the most astonishing results of the application of chemistry to vegetable life and organization, is embraced in the discoveries, that,

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*(Note 2.) †(Note 3.) ‡(Note 4.)

1st. Nineteen-twentieths by weight, of all vegetables, are derived originally from the air we breathe;

2nd. The atmospheric food of plants exists in the forms of carbonic acid, water and ammonia.

These important principles in agricultural chemistry may be made more evident, by the following illustration: Let us suppose we burn completely 1000 lbs. weight of hard wood in a stove or fire-place, and carefully weigh the ashes which remain behind. They will be found to constitute about one-twentieth of the whole mass of the wood, weighing not more than from 30 to 50 lbs., according to the kind of wood burnt. The whole of that portion which goes off in the form of smoke, vapour of water and gases, existed at one period in the air we breathe, in the forms of carbonic acid, water and ammonia. The whole of the ashes were obtained from the soil in which the trees originally grew.

We may now proceed to consider the properties and sources of the atmospheric food of vegetables, and endeavour to ascertain the manner in which it assists in building up their structure, also to what extent the formation of the different parts of vegetables is dependent upon a proper supply of each particular kind of food.

Carbonic Acid.—*This important food of vegetables possesses many singular properties. It is poisonous to animals, and cannot support combustion. Water absorbs it with avidity, and thus acquires the power of dissolving chalk and limestone. It is also the most active agent in loosening and separating into their constituent parts, the surfaces of solid rocks, stones and soils. In 22 lbs. weight of carbonic acid, there are 6 lbs. of carbon or charcoal, and 16 lbs. of oxygen. The leaves of plants absorb it from the air by which they are surrounded, *during the day time;* or take it up in water which enters at their roots, in both cases light must fall upon the leaf to enable the plant to separate the carbon from the oxygen, which is returned

*(Note 5.)

to the air in its pure form of a simple gas. During the night time, whatever carbonic acid is contained in the water sucked up by the roots, is immediately given off by the leaves; few plants having any power to separate the carbon from the oxygen during the darkness of night. A popular opinion prevails that some plants possess the power of turning their leaves to the sun. The motion observed is purely mechanical, and depends upon the rapid liberation of carbon from the absorbed carbonic acid in those parts of the plant which are exposed to the direct rays of the sun. The liberated carbon stiffens and contracts one side of the plant in forming new wood, while the other remains comparatively flexible. The contracted side becomes arched, and appears to give to the vegetable a limited power of motion in the direction of light—a brilliant artificial illumination produces the same effect in the ratio of its intensity. When carbon is separated from carbonic acid, it combines with the component parts of water, and forms woody fibre, starch, gum, sugar and oils. Carbon obtained from carbonic acid forms from 45 to 50 lbs. in every 100 of the dry wood, stalks and seeds of cultivated plants. The constant presence of carbonic acid in the air we breathe is due to the respiration of animals, the combustion of burning bodies, and the decay of vegetable matter. A vast store exists in the extensive limestone rocks which form a large portion of the earth's crust. Pure limestone is composed of one-half lime and one-half carbonic acid, which may be driven off in the gaseous form by means of a violent heat, as in the operations of limekilns.

[The carbon contained in the vegetable matter of fertile soils, (decaying roots, leaves &c.,) slowly combines with the oxygen of the air, and forms carbonic acid, which is absorbed by water and thus taken into the system of vegetables. It is from this source that they derive their supply of carbonic acid before they have thrown out many leaves. "Each new leaf furnishes them with another mouth and stomach." The power of absorbing carbonic acid from the atmosphere is proportionate to the surface of the leaves. Straight and narrow leaved plants, those which are grown for their seed, as wheat, rye, oats, barley, depend more upon the soil, for their supply of carbonic acid, than the Jerusalem artichoke, the mangel wurtzel, or the beetroot, which are grown for the sake of their roots. The great size of the roots, stalks and leaves of the root crops would lead us to suppose that they contained a much larger quantity of carbon than the grain growing crops—this is not strictly the case—and the reason is found to lie in the fact that, roots of turnips, mangel wurtzel, beets, potatoes, contain from 700 to 900 parts of water in 1000 of the fresh roots—whereas, the quantity of water in grasses and grain, varies from 120 to 150 pts. in the thousand. It is thus that grain crops exhaust the soil of vegetable matter, and consequently of the means for supplying carbonic acid to the young plants; they take more carbon from the soil, than they leave behind in the form of decaying roots and stubble. The roots of clover, the grasses, and the leaves of turnips, mangel wurtzel &c., which are usually left upon the land, contain more carbon than the whole of the crop abstracted from the soil during its growth. A judicious rotation of crops leaves the land richer in vegetable matter than before the rotation began.]

Water.—This abundant and necessary fluid is known to the agriculturist in four states, the solid, (ice,) the fluid, (water,) the gaseous (vapour of water, steam,) and in combination with certain bodies, (slacked lime.) When water freezes, that is, assumes the solid state, it expands with astonishing force, sufficient to break the strongest vessels. Many remarkable results are produced by the expansion of water when converted into ice, among which, the floating of ice is, perhaps, the most deserving of notice. If water, in becoming solid, followed the almost universal law of contraction, ice would sink, and yearly increasing in thickness at the bottom of deep seas, lakes and rivers, would produce such a change in climate as probably to convert the greater portion of the temperate zones into desolate and uninhabitable regions. We discover, however, a still more beautiful provision for arresting the conversion of oceans and seas into solid masses of ice, in the singular property of water occupying the least space, and being consequently heaviest, at the temperature of 40 degrees—eight above the freezing point. The warmth of seas, at depths beyond the influence of the sun's heating rays, is thus perfectly uniform, effectually preventing the Arctic Oceans from becoming solid and immoveable masses of ice. During the Summer and Autumnal months rain and dews penetrate the minute crevices and pores of solid rocks and clods of earth; in the winter months the water freezes, and expanding, tears their particles asunder; thus gradually reduces the hardest rocks into a soft and friable soil. To the alternate thawing and freezing of water in the soil during the early spring months, and its consequent contraction and expansion, the "throwing out" of young wheat plants is to be attributed, a disaster which may be materially prevented by draining. When water is changed into steam or goes off into the form of insensible perspiration, it absorbs a vast quantity of heat.* This property should be well remembered by farmers, since if evaporation takes place to a great extent from the soil, its natural warmth is abstracted and the chill produced greatly checks and retards vegetation. Most solids and gases are soluble in water; the very existence of vegetables and animals is dependent upon this property. It is thus that river and well water contains small quantities of lime, potash, soda, magnesia, iron, besides air and carbonic acid. The refreshing and agreeable taste of springs is due to the presence of dissolved air; hence, also, recently boiled water is insipid and disagreeable.

Water is composed of two gases, Oxygen, before described, and Hydrogen,† a very light and inflammable gaseous body. If we mix 8 pounds of hydrogen with 1 pound of oxygen, and pass an electric spark through the mixture, a loud explosion will take place, and 9 pounds of water be formed. Chemists are acquainted with various

*(Note 6.) †(Note 7.)

ways of converting water into its component gases. The perfectly clean surface of many metals, such as iron, zinc, copper, &c., will immediately take oxygen from water, and liberate a corresponding quantity of hydrogen, which at once assumes the gaseous state. The oxygen separated by the metal forms with it a rust or oxide of the metal. Plants possess the power of decomposing water, and make use of its components to build up their structure.

Ammonia.—Ammonia, in popular language, Spirit of Hartshorn, is formed in the air by the action of lightning. It is composed of hydrogen and nitrogen. Three pounds of the former combining with fourteen pounds of the latter to form seventeen pounds of ammonia. This body possesses a singularly powerful odour, and an equally remarkable attraction for water, which dissolves 780 times its volume at the temperature of melting ice. Ammonia is emitted from decaying vegetables and animal matter; it is also found in the perspiration of animals and given off from the leaves of many plants, as well as from the flowers of a still greater number. Rain water always contains ammonia, washed from the air through which it passes. The characteristic smell of close stables is due to ammonia proceeding from the decomposing urine. Many solid bodies exhibit the power of absorbing large quantities of ammonia—such as partially burnt clay, rust of iron, gypsum, and especially powdered charcoal aud decayed wood: these substances relinquish much of what they have condensed within their pores, to the water with which they may be saturated. Ammonia *is a very important* portion of the food of vegetables.

It has been remarked that the three bodies Carbonic Acid, Water, and Ammonia, constitute nine-tenths of the food of vegetables, and are composed of four simple or elementary bodies, thus,

Carbonic Acid, from Carbon and Oxygen;
Water, from Oxygen and Hydrogen;
Ammonia, from Hydrogen and Nitrogen.

The ratios in which these simple substances enter into the composition of vegetables is nearly the same for all species. If the wood of the oak, the beech, the elm, the maple, or the straw and seeds of wheat, barley, oats, &c., be dried in an oven, so as to drive away all moisture, and the remaining portion subjected to analysis, it will be found that these, and indeed all vegetables contain in every hundred pounds weight,

From 40 to 50 lbs. of Carbon,
" 35 to 45 - - - Oxygen,
" 5 to 7 - - - Hydrogen,
" 1 to 3 - - - Nitrogen,
" 2 to 10 - - - Ash.

A more exact composition of some important vegetables is given in the following table:—

	Carbon. lbs.	Hy' gen. lbs.	Oxygen. lbs.	Ni'gen. lbs.	Ash. lbs.		
Wheat,........	46.1	5.8	43.4	2.3	2.4	=	100.
Oats,..........	50.7	6.4	36.7	.2	4.0	=	100.
Wheat Straw,...	48.4	5.3	38.9	.4	7.9	=	100.
Oat Straw,.....	50.1	5.4	39.0	.4	5.1	=	100.
Clover Hay, (red).	47.4	5.0	37.8	2.1	7.7	=	100.

In illustration of the above tables—let us take as an example—Red Clover Hay. We find that 100 lbs. when well dried, is composed of $47\frac{4}{10}$ lbs. of carbon, 5 lbs. of hydrogen, $37\frac{8}{10}$ lbs. of oxygen, $2\frac{1}{10}$ lbs. of nitrogen, and $7\frac{7}{10}$ of ash. Or, in other words, $92\frac{3}{10}$ lbs. out of 100, obtained from the three substances Carbonic Acid, Water and Ammonia, and only $7\frac{7}{10}$ lbs. out of 100 lbs. derived from the solid substances of the earth.

When vegetables decay, many and very complex changes take place, but all these finally result in those which restore to the air we breathe, and the soil we tread upon, the substances from which the plant was constructed. "All the innumerable products of vitality resume, after death, the *original form* from which they sprung. Thus, the destruction of an existing generation becomes the means for the productionof a new one, and death becomes the source of life."—(Liebig.)

The extremities of the roots of vegetables are similar in their construction to a sponge. They consist of a number of exceedingly small openings or mouths, through which water, containing solids in solution, is alone capable of entering. It is thus that water forms the means of introducing into vegetables various mineral substances, which are absolutely necessary to their growth, as essential indeed, to the perfection of their different organs, as the air and its admixtures. During the winter months important additions are furnished to the ends of the roots, in the form of new spongy extremities, which enable them to commence early and active absorbing operations in the first warm days of spring.

We now arrive at another principle in Agricultural Chemistry, briefly enunciated as follows:—

BEFORE ANY SOLID CAN ENTER INTO THE COMPOSITION OF VEGETABLES, IT MUST BE IN A STATE OF SOLUTION IN WATER.

The general structure of a vegetable is admirably adapted to the conditions under which it exists. Its leaves are continually bathed in an atmosphere containing the main source of its food, while its roots repose in a soil where abundance of moisture is ready to convey into its interior those mineral ingredients which assist the plant in digesting and assimilating its atmospheric nutriment. The leaves are employed during the day time in incessantly searching from the moving air which agitates them, the carbonic acid which supplies them with carbon: the roots are engaged in drinking from the earth a copious supply of water containing ammonia and solid substances in solution. These, the vital energies of the plant, fabricates together, and forms from their crude elements its varied and beautiful tissues.

The quantity of water transmitted through the system of plants is immense. From the leaves* of a well wooded acre of land, not less than three-hundred thousand gallons pass off in the form of invisible vapour during the four months intervening May and October.

*(Note 8.)

We may imagine how easily disease in vegetables is engendered, when evaporation from their leaves is suppressed by any external causes. (The potatoe disease, rust on wheat, mildew, &c.)

THE SOIL.—The uniform constitution of the atmosphere differs widely from the heterogeneous mixture we meet with in soils, which are as variously compounded as the rocks upon which they repose. The elements forming common air are few in number, and simple in character. The substances we find in soils are frequently numerous, and often complex in their constitution. All soils spring originally from the disintegration and decomposition of solid rocks; the agents most active in effecting these changes are water, temperature, air, and vegetables themselves. Various bodies are found in soils, which do not enter into the composition of vegetables. In an elementary view of Agricultural Chemistry, we do not require to consider their properties, without their presence effects such a change in the relations of the soil to temperature and moisture as seriously to affect the growth of vegetables. It is sufficient for our present purpose if we consider the relation to vegetable life, of certain ingredients which necessarily enter into their composition, and invariably form part of fertile soils.

The transmission of water through the roots and stems of vegetables, and its final escape at the leaf, furnish us with the remarkable mode in which dissolved solids are conveyed into their interior, and made to assist in the formation of their different organs. These solids are nine or ten in number, and are named respectively,

1. SULPHUR; 2. PHOSPHORUS; 3. POTASH; 4. SODA; 5. LIME; 6. MAGNESIA; 7. IRON; 8. FLINT; 9. CHLORINE; 10. IODINE.

Water possesses the property of dissolving small quantities of these bodies, either directly or indirectly; all, with the exception of Iodine are required by land plants, and they constitute what is termed the 'Ash', when vegetable substances are burned in the open air.

The quantity of ash found in cultivated vegetables varies remarkably with the nature of the soil, and the species under examination. It is evident that every fertile soil contains the constituents of ash in abundance, also in *such a state*, that enough for the wants of the growing crop, ARE SOLUBLE IN WATER, in order that they may be conveyed into the interior of the vegetable.

The waters of rivers, springs and wells always contain a small quantity of various solids in a state of solution. By washing a soil repeatedly with pure rain water, we find that each time of washing the quantity of some of the substances dissolved is diminished, until, at length, no portion is taken up. It is evident that a large supply of soluble substances, can not exist in ordinary soils, exposed to rains, snow, and dews. Every little stream is bearing its load of dissolved materials, to that great storehouse and depository, the Sea. The continual action of rains washing out the soluble portions, and either conveying them altogether away, or transporting them into the subsoil below, coupled with repeated croping without the return of one particle in the form of manure, must, in the long run of years, render the most fertile soil destitute of soluble mineral substances, and consequently unfruitful. The quantity yearly abstracted by these means may be perfectly insignificant compared with the abundant store remaining behind—that small quantity, nevertheless, is of vital importance,—for, although there may be thousands of tons of sulphur, potash, soda &c., present in the soil, yet IF NO PORTION IS SOLUBLE IN WATER, the soil, with reference to immediate agricultural purposes, is absolutely barren The fertility of such a soil can be restored by the hand of time ; and its restoration can be accelerated by those means which science suggests, and experience approves, for giving solubility to as much as will satisfy the imperative demands of growing crops.

The analysis of a good crop of wheat will exhibit the quantity of solid ingredients abstracted from the soil during its growth, and conveyed away in the straw and grain.

A crop of twenty-five bushels to the acre, contains about 200 lbs. of solid mineral ingredients: an average crop of clover from 250 to 300 lbs. of solid mineral ingredients.

These quantities appear to be small, but when we consider that in many parts of this Province, little return is made in the form of manure, that crop after crop of the same kind of vegetable is often grown for years together, and that rains are continually washing out, and streams and rivers bearing to the sea, the soluble ingredients of the soil—when we associate these considerations with the circumstance, that it requires many months and even years for temperature, moisture, and air, to render soluble in water a sufficient quantity of each particular kind of ingredient required by growing crops, we can not be surprised that complaints are made of diminishing scales of produce.

SULPHUR.—Certain organs or parts of plants require for their formation a small amount of sulphur. It is of no importance to know, at present, the name and disposition of those organs; the bare fact that the presence of sulphur is absolutely necessary will determine the agriculturist in investigating the subject.

In 10,000 lbs.	of the ash	of wheat		there were found	12 lbs.	sulphur.
do.	"	"	do. straw,	"	40 "	"
do.	"	"	oat grain,	"	40 "	"
do.	"	"	do. straw,	"	90 "	"
do.	"	"	Hay,	"	151 "	"
do.	"	"	Vetch,	"	170 "	"
do.	"	"	Peas,	"	171 "	"

These numbers vary slightly with the nature of the soil; they serve, however, to show the *kind* of plants which require much sulphur, to which may be added hops, asparagus, sugar cane, grape, black and white mustard, turnips, tobacco, &c. Wheat, barley, rye and indian corn, require comparatively little sulphur. The most common and widely extended source of sulphur in soils, is doubtless gypsum or sulphate of lime, (sulphuric acid or oil of vitriol, combined with lime.) A barrel of gypsum contains about 33 lbs. of sulphur and 116 lbs. of lime, the remaining portion consisting of oxygen. Gypsum is slightly soluble in water; its effects when spread upon the land, are greatly increased by mixing with it an equal quantity of common salt before sowing. The quantity of sulphur, annually taken from the soil in Canada is enormous. A very insignificant portion ever finds its way back to the soil, on account of its being bound up in those materials which rarely swell the manure heap. This useful substance is found in considerable quantities in the wool of sheep, in the hair and skin of animals generally, it is also invariably met with in urine.

In 1848, Canada exported 3,500,000 bushels of wheat, which contained of sulphur alone, no less than 252,000 lbs.; in the same year she raised 2,339,756 lbs. of wool, which, with the wasted urine, &c., contained at least an equal amount, making a sum total of half a million pounds of sulphur, abstracted from the soil, without the possibility of one particle being returned to it from these sources, in the form of manure.

PHOSPHORUS.—Phosphorus is found in the seeds of most vegetables, especially those cultivated for food. A very large quantity is annually taken from the soil. In 1847–8 Canada exported in the grain of wheat not less than 733,500 lbs.

[When phosphorus is burned in the air, it emits a very copious volume of white smoke, which consists of phosphorus, combined with oxygen. The white smoke may be collected and dissolved in water. It has a sour taste, is therefore an acid, andis named phosphoric acid. Now, when lime, potash, soda, magnesia, iron, &c., come in contact with phosphoric acid, a union takes place and a number of new bodies are formed, which all go by the general designation of phosphates; thus a compound of phosphoric acid and lime, is called phosphate of lime, of phosphoric acid and iron, phosphate of iron, &c. &c.]

Phosphoric Acid is always found in very minute quantities in primitive rocks, when sought for. Its detection is frequently a matter of some difficulty: it exists in all soils, often, however, in a state very insoluble in water, and it is one of those bodies, which like sulphur, do not, under ordinary circumstances find their way to the manure heap. Phosphorus is found in many parts of the animal frame, especially in the bones. England imports annually very large quantities of bones for the purposes of manure. The bones are either crushed or dissolved in sulphuric acid, and applied to the soil, in order to restore a small portion of the phosphorus which, during centuries of cultivation, has been washed away by rains, or abstracted by crops. So far back as 1827, England imported 40,000 tons of bones, having a value of 600,000 dollars.

Since that period a great increase has taken place in the trade, so much so, that many large vessels are now employed in conveying from South and North America, and from various parts of Europe, the bones of animals to fertilize the fields of England. No grain crops can succeed in a soil destitute of a supply of soluble phosphates; and one pound of bones contains as much phosphorus as is required by one hundred pounds of wheat. At the lowest calculation enough phosphorus was exported from Canada in the year 1847-8 to build up the bony framework or skeleton, of sixty-thousand full-grown men. Every good cow in one year abstracts from the soil, as much phosphorus as is contained in 80-100 lbs. of bones, much of which enters into the composition of milk, and the remainder is *lost* in the urine, (see urine.) Pure phosphate of lime, (the substance which gives strength to the bones) is found in many parts of Canada, in certain rocks. The time may not be far distant when it will be profitable to collect and grind it for agricultural purposes.

POTASH, SODA AND MAGNESIA.

These substances exist in variable quantities in all cultivated crops. Vegetables appear to possess a limited power of making indiscriminate use of them, especially of potash and soda. This is not the case with sulphur and phosphorus; no seed nor *nutritious* juice, can be formed without definite quantities of each. A few examples will serve to illustrate the very variable quantities in which potash, soda and magnesia are introduced into wheat. In six analyses of wheat made by celebrated chemists, there were found in 100 lbs. of the ash, in

No. 1.	26	lbs.	Potash,	No. 2.	6	lbs.	Potash,
	6	do.	Magnesia,		13	do.	Magnesia,
	½	do.	Soda.		28	do.	Soda.
No. 3.	24	lbs.	Potash,	No. 4.	30	lbs.	Potash,
	13½	do.	Magnesia,		16¼	do.	Magnesia,
	10⅓	do.	Soda.		0	do.	Soda.
No. 5.	33¾	lbs.	Potash,	No. 6.	21¾	lbs.	Potash
	13½	do.	Magnesia,		9½	do.	Magnesia,
	0	do.	Soda.		15¾	do.	Soda.

Red Clover, Potatoes, and especially Potato tops, Beetroots, Mangel Wurtzel and Peas, in a word most green crops require much potash, soda and magnesia. A comparatively small quantity of these substances will satisfy grain-growing crops.

An acre of Clover abstracts from - -	90—100 lbs.
do. of Beetroot or Mangel Wurtzel,	80—100 do.
do. of Potato tops, - - - - -	130—150 do.
do. of grain and straw of Wheat, -	30— 50 do.

The large quantity of Potash and Soda in Potato tops, contradicts the impression frequently found to prevail, that they are of little use as manure.

Lime.—A very important constituent of all vegetables cultivated for the food and use of man—and if possible an equally important agent in the hands of the agriculturist for ameliorating the condition of many kinds of soil. Its effects as a manure will be considered under that head; it is sufficient for our present purpose to become acquainted with those kinds of vegetables which particularly require lime for the due formation of their various organs.

An Acre of Clover	abstracts	from	70—90	lbs. of	Lime.
do. Hay,	do.	do.	30—50	do.	do.
do. Wheat Straw,		do.	15—20	do.	do.
do. Oat Straw,	do.	do.	10—18	do.	do.

Various vegetables possess the power of assimilating more than an average quantity of lime, if presented to them in a proper form. Its effects upon the straw of grain-growing crops is very remarkable. Farmers are acquainted with lime in three different states,—1st. in the form of common limestone, which consists of lime and carbonic acid; 44 lbs. of carbonic acid and 56 lbs. of pure lime, forming 100 lbs. of common limestone, which, when burned in a kiln, parts with the carbonic acid and then constitutes; 2nd. quick or caustic lime; 3rd, in the form of slacked lime. When 9 lbs. of water are thrown upon 28 lbs. of caustic lime, the lime swells, evolves great heat, and entering into combination with the water produces 37 lbs. of slacked lime. Lime is found in the soil in the state of carbonate of lime, its presence is indicated by effervescence when an acid is poured over it. In the caustic state it possesses very powerful properties, causing the rapid decomposition of vegetable and animal substances.

Flint.—Called by chemists Silica, composes a large proportion of the ash in all grain growing-plants; its office in vegetables is to give strength to those parts which seem particularly to require additional aids. The wheat plant affords an admirable illustration of elegance in form united with wonderful strength. A column 576 feet high and 3 feet in diameter, bearing a weight upon its summit equal to that of the column itself, represents a multiple of a wheat plant four feet high and one-fourth of an inch in diameter. No selection of materials, or contrivance in binding them together, would enable an artificial structure of these proportions, to resist the force exerted by a gentle breeze.

A good crop of Wheat, from one acre, abstracts in the straw alone from 120 to 150 lbs. of Flint; of Oats, seed and straw, from 40 to 60 lbs.; Mangel Wurtzel and Beets, from 12 to 18 lbs. of Flint.

IRON.—Iron is present in all fertile soils, and is also an invariable constituent of vegetables. It greatly increases the tenacity of clays when found in the soil in the state of black oxide or rust of iron,—it may be converted into the red oxide or rust by exposure to air. The black oxide is soluble in water and prejudicial to vegetables: the red oxide is sparingly soluble, and a harmless or rather useful product. Iron is found in all the clay soils of Canada, in the form of the black magnetic oxide of iron: on the shores of lakes Ontario, Simcoe, Huron, St. Clair, &c., it occurs in very large quantities mixed with white and red sand—it may be separated by means of a magnet.

CHLORINE.—This substance does not exist in a simple or pure state; it is always found in combination with other bodies: common salt is the great storehouse of chlorine. Salt is composed of a metal sodium in union with chlorine. When used as a manure salt yields soda and chlorine to vegetables.

IODINE is only found in sea plants, or those growing in the immediate neighbourhood of salt water.

It will be observed that different kinds of cultivated vegetables, require for their due formation, different quantities of flint, lime, potash and soda. A variety of convenient and useful arrangements of vegetables, can be framed on the basis of their respective requirements. Thus we have as a very general and necessarily imperfect method of arrangement, the following, flint, potash and lime plants—

Flint Plants.	Potash and Soda Plants.	Lime Plants.
Wheat,	Turnips,	Peas,
Oats,	Beet-root,	Beans,
Rye,	Mangel Wurtzel,	Clover,
Barley,	Indian Corn,	Tobacco.
	Potatoes.	

Hay partaking of the character of the three classes (Liebig.)

Other, and more exact modes of arrangement of different kinds of vegetables with reference to each other, naturally suggest themselves, when the number under consideration is diminished; these will be introduced hereafter, under 'Rotation of Crops.'

The recent analysis of a soil—from the Seignory of Chambly, in Lower Canada, by T. S. Hunt, Esq., Chemist and Mineralogist to the Provincial Geological Survey,—"exhausted by having yielded crops of wheat for many successive years without receiving any manure," gave the following results:

In 100,000 lbs. of the soil there were found, of

Lime 374 lbs.,	Sulphuric Acid 31 lbs.,
Magnesia 888 lbs.,	Phosphoric Acid 126 lbs.,
Potash and Soda 580 lbs.,	Soluble Flint, 80 lbs.,

We here discover an abundance of all the necessary substances which plants require. The plea of deficiency therefore cannot obtain, in this instance. The present barrenness of the soil is unquestionably due to the *state* in which some of those bodies exist at present. This view is confirmed by the remark of Mr. Hunt, that it supported nothing but "a scanty growth of a short wiry grass, which is regarded as indicative of an impoverished soil, and known as *herbe à cheval.*"

The same soil when subjected to the action of water, gave only minute traces of sulphates of lime, magnesia, potash and soda; there being proportionately two pounds of sulphur in one million pounds of the water with which the soil was treated, while analysis showed that there was upwards of three thousand one hundred pounds of sulphur in one million pounds of the soil, *in an insoluble state.* No mention is made of phosphates soluble in water, therefore we may conclude that the quantity was too insignificant to be detected by ordinary means of analysis.

We have had under consideration a soil, which at one period was eminently fertile—having yielded successive crops of wheat for 30 years,—at present, however, barren, and yet possessing in abundance, a supply of all needful substances for thousands of crops of wheat, or any other vegetable which at the pleasure of the cultivator could be grown upon it. The present example affords a good illustration of the condition of other soils which have been subjected to an injudicious course of cropping. It becomes then, a question of much interest and moment to practical farmers, to ascertain the nature of those artifices they must employ in order to restore and render permanent the fertility of such depreciated soils.

The chief agent in effecting the solubility of the necessary quantity of mineral substances is Air. All the operations of the farmer are in the main directed to the introduction of air into the soil, and affording time for its influence to be exerted. He ploughs for the purpose of exposing fresh surfaces to air; he drains to admit air into its pores and crevices; he fallows to give time for air to exert its powerful influence; he employs a rotation of crops for precisely the same object.

Ploughing.—It has been remarked that the beneficial effects produced by ploughing, are mainly due to the free admission that operation gives to the air, whereby the decomposition of the mineral portion of the soil is greatly facilitated, as well as the conversion of decaying vegetable matter into carbonic acid, ammonia and water. Air is necessary to the germination of seeds, hence the reason why so many different kinds of weeds spring up when the soil is first stirred to the depth of six or eight inches, the dormant vitality of the seeds being revived under its powerful influence. Ploughing also cleanses the soil from weeds, and rendering it more porous, it permits the young and tender roots of plants to penetrate in search of food—it also facilitates the absorbtion of rain water.

Many clays contain a quantity of iron in the form of the black rust of iron, a substance noxious to vegetables; in the presence of air it is converted into the red rust of iron, a harmless compound. The change in the character of the iron rust destroys the stiffness and tenacity of the clays, and converts them into comparatively loose and friable soils. Farmers frequently skim the surface of their fields with the plough. It is evident from the rationale of the operation that the deeper the plough penetrates, the greater benefit is likely to result.

The subsoil plough is much used in Great Britain,—it serves to break up and loosen the earth 10 or 12 inches below the limit to which the common plough penetrates. Subsoil ploughing is of little avail on soils possessing a retentive bottom, without thorough draining.

DRAINING.—The extensive introduction of a proper system of draining, constitutes, unquestionably, the great modern improvement in the Art of Agriculture.

Its effects are due,

1st. To the greatly increased porosity of drained soils, allowing the circulation of air among their particles with every change of temperature.

2nd. To the rapid removal of superfluous and stagnant water, which on undrained soils fills the pores or small spaces between their solid particles and opposes the introduction of air into its place.

3rd. To the alteration which takes place in the mechanical composition of the soil, whereby it is rendered loose, friable, more easily worked, and at an earlier period of the year than when undrained.

4th. To the great change it produces in the temperature of the soil.

Recent experiments have satisfactorily established that the evaporation of one pound of superfluous or drainage water, that is, of one pound of water, over and above the quantity which a soil is capable of retaining by its power of attraction or absorbtion, lowers the temperature of the soil ten degrees. If the one pound of water pass off by the drains, and not by evaporation, no reduction in temperature takes place.

The mean highest temperature of the air in March, (the earliest agricultural month in Canada,) is 54 degrees. The warm sun melts the snow and frozen surface of the soil. If thoroughly drained, the water will slowly filter to the drains during some hours of the day-time, and air at the temperature of from 50 to 54 degrees *will follow the water*,—thawing, before it is cooled much, frozen soil. In April the mean highest temperature is 71 degrees, the mean temperature 42 degrees; during many hours of the day, warm air, on drained soils, will follow the water, and rapidly impart much of its warmth around and below the young roots of plants, thus inducing an early and rapid growth in that very important part of the plant. Experiments have been made in England on the temperature of undrained soils; they exhibited the singular and very important fact, that the temperature of a wet soil *never* rose during many months above 47 degrees—seven inches below the surface. The same soil when drained indicated a temperature, after a thunder storm, of 66 degrees at 7 inches below the surface, and at a depth of two feet seven inches, a temperature of 48 degrees. What would be the effect in this country where the temperature of air and rain is so much greater than in England?

[A very large number of solid bodies exhibit an attraction for water, as wood, glass, iron, &c. All fatty bodies and oils, show a decided repulsion for the particles of water; they cannot be wetted by it. Water will remain attached to the surface of a clean piece of glass, even when turned upside down; common quicksilver would roll off from glass, but not from a clean piece of zinc. Zinc can be wetted by quicksilver when the surface is free from rust. Let us suppose that a thin and very narrow piece of glass be bent round, so as to form a long and exceedingly narrow tube; if the end of the tube be placed in water, the fluid will be seen to rise rapidly, until the attraction of the glass for water is exactly counterbalanced by the weight drawn up. Such a tube is called a capillary tube. and the force exerted by the glass, or any other body having the form of a fine tube, capillary attraction. The roots of plants consist of an assemblage of exceedingly fine tubes,—all porous bodies, in fact, may be considered as bundles of small tubes, their length and direction not affecting their attractive power for water. It is thus that soils which are very porous, absorb and retain water—the fluid absorbed is called their *water of attraction*. If a lump of clay be completely dried in an oven, afterwards suspended by a string and water poured slowly upon it, a large quantity will be absorbed.

Thus from 106 lbs. of dry soil, water will begin to drop, if it be a quartz sand, when it has absorbed	25 lbs.
Calcareous sand (lime sand)	29 do.
Loamy Soil	40 do.
Chalk	45 do.
Clay Loam	50 do.
Pure Clay	70 do. (Johnston)

When water of attraction slowly disappears during the process of evaporation, the soil contracts and occasions fissures, this effect is particularly observable on clay soils. It is worthy of remark, that soils absorb much moisture from the atmosphere. "Different soils possess this property in unequal degrees. During a night of 12 hours, and when the air is moist, according to Schübler, 1000 of a perfectly dry

Quartzy Sand will gain	0 lbs. of water.
Calcareous Sand	2 do.
Loamy Soil	21 do.
Clay Loam	25 do.
Pure Agricultural Clay	27 do.

And peaty soils, or such as are rich in vegetable matter, a still larger quantity." We discover in this property the reason why potato plants always appear refreshed in dry weather, after the earth has been stirred by the hoe round about their roots. The soil is made more porous, in effect a much larger surface is exposed to the air and the moisture it may contain—the moisture is absorbed, and ministers to the growth of the drooping plants.]

It is occasionally urged by practical farmers, that thorough draining will not succeed in the hot and dry summer season of Canada. This is a mistake, the roots of vegetables shun stagnant water, they turn aside when their descent would bring them in contact with it. They will penetrate many feet into the soil if it be well drained. But what is the case with our Canadian fields? When the roots of wheat or other vegetables begin to grow in the spring months, they discover at the depth of six or seven inches, a supply of stagnant water, which can find no escape but by cold-producing evaporation. The roots are not only chilled, but absolutely prevented from penetrating deeper in search of nutriment, they can not thrive when surrounded by drainage water, their growth is retarded, and their range limited; on a drained soil they strike directly downwards to the level of the drains, and in those depths, they discover a supply of moisture in seasons of drought, springing up from below by the power of capillary attraction, besides that which every soil possesses the power of absorbing. It has been ascertained by vegetable physiologists, that roots cease to grow, as soon as the plant begins to form the seed. Its energies are then exclusively devoted to that object. The formation of the seed, in many kinds of cultivated grain growing crops, begins in June or early in July. A dry summer parches the soil to the depth of five or six inches. The limited depth to which the roots have penetrated, prevents them from obtaining a sufficiency of moisture, the crop consequently suffers from drought, a disaster which has taken place to a very large extent this year, with respect to clover and hay, and if the dry weather had continued a fortnight longer, the labors and hopes of the farmer, in many parts of the province, would have been altogether defeated. Comparatively little damage would have been done on drained soils, for the roots of vegetables, following their own natural tendencies, would have been able to penetrate during the early spring months, deep into the soil, and there find a supply of moisture, removed from the rapidly evaporating influence of a hot sun and a dry atmosphere.

[The great obstacle to thorough draining in Canada, is the *expense*—coupled with the low price of farming produce. Within a convenient distance from large towns, where a market for wheat, oats, hay, peas, tnrnips, mangel wurtzel, is generally to be obtained, this objection can scarcely hold good. The great increase in the average prcduce, the superiority of the sample, the early maturity of the crops, their comparative safety from the effects of drought and the fly: all support the presumption of a rapid and profitable return for an outlay of capital. In districts remote from markets, the expense of thorough draining constitutes an insuperable objection to its introduction. Much good can, however, be accomplished by clean open furrows 10 or 12 inches deep—and so cut that they may admit of a continuous fall of water through their whole length, so that no portion may remain in any part of the furrow. An inclination of one foot in three hundred will be quite sufficient to cause an unbroken current, if the fall be quite uniform. Where the land lies low, the most beneficial results will be produced by a drain, dug to the depth of two feet, with here and there a hole to the depth of three and a-half or four feet—the holes and drain being filled up to within one foot from the surface, with stones from two to six inches in diameter, then covered with a sod, trampled down, and filled up with earth. It may here be remarked, that open drains with an occasional under-ground drain, require more care in construction than is usually devoted to them. Thorough draining is an art in itself, and implies an acquaintance with the characteristics of springs, soils and climate, besides a practical knowledge of levelling. A recent writer on draining, possessed of thirty six years experience, closes his remarks with the following caution. "Our parting words shall assure our readers, that every reputed case of failure in draining, which we have investigated, has resolved itself into ignorance, blundering, bad materials, and bad execution." The same writer recommends the use of pipes, having an inch or inch and half bore, with collars to lay over the joinings, and prevent dis-arrangement. Collars are short pipes which slip over the joinings of two contiguous drain pipes, and effectually prevent the uniformity of the juncture from being disturbed by 'faults' in the floor of the drain, or by an *upheaval.*]

Fallowing.—A Fallow implies the repose of the soil, or in other words time, to permit air, water, and temper-

ATURE, to convert a certain amount of insoluble ingredients in the soil, into soluble and available food for plants. A naked fallow is deprecated by many practical agriculturists and agricultural writers—they consider it as so much land thrown away for a time, and propose in its stead a judicious rotation of crops. It is very questionable, however, whether a naked fallow is not occasionally absolutely necessary in this country, where the growth of weeds is extremely rapid, and where the high price of labour is always an obstacle to many hands being employed upon a farm. A naked summer fallow seems to offer to the Canadian farmer the most available and cheapest method of cleaning his fields, especially where numerous patches of uncultivated land, every road side, and every neglected farm is a nursery for Canada thistles, wild mustard, wild chamomile, chess, mullen, foxtail, burrs, and other noxious weeds. Green Fallow, is a term used with reference to the cultivation of wheat, rye, barley, and oats. The principles it involves will be introduced under the head of,

ROTATION OF CROPS.—The origin and constitution of some favoured soils, is such as to require the active operation of air for a very limited period, to enable them to offer an abundant supply of soluble solid food for the purposes of vegetables, without any extended rotation of crops. Wheat, a flint plant, and tobaccco a lime plant, have been grown alternately on large tracts of land in Hungary, within the memory of man, without any application of manure. In many parts of Upper and Lower Canada, in the valley of the Thames and the Richelieu, wheat has been taken from the soil for 40 and even 50 successive years, the soil eventually becoming incapable of returning a profitable crop. The repose of a fallow for a few years, restores its fertility. During the period of fallow, air, water, and temperature, exert their decomposing influence, upon the soil, and convert an abundance of insoluble mineral ingredients into soluble food for vegetables. The alternate growth of wheat and tobacco, upon the fertile soil of Hungary, presents us with an easy and familiar illustration of the benefits springing from a rotation of crops. Wheat requires a large amount of flint; tobacco, an equal quantity of lime. While the wheat is growing, the lime in a soluble state, is accumulating in the soil, and the growth of the tobacco, acts as a fallow for the preparation of the soil for wheat, because tobacco does not require those particular ingredients, which are essential to the growth of wheat.

It will be seen that the principle of a rotation of crops depends upon the cultivation of a Flint plant one year, a Potash plant the next, and a Lime plant the third, and so on. The character of the soil determines whether one, two, three or four years should intervene the introduction of different kinds of vegetables.

The following table given by Liebeg, may afford an apt illustration of this important principle. In 100lbs of the ash of the following vegetables, the proportion of Potash and Soda, Lime and Magnesia, and Flint, are given under their respective heads.

		Pot. and Soda.	Lime and Mag.	Flint.
Flint Plants	Oats, straw and seed,	34lbs.	4lbs.	62lbs
	Wheat straw, ...	22 "	7 "	61 "
	Barley straw and seed	19 "	25 "	55 "
	Rye straw, ...	18 "	16 "	64 "
Lime and Magnesia Plants.	Tobacco,...........	24 "	67 "	8 "
	Pea straw, ...	28 "	64 "	8 "
	Potato Stalks, ...	4 "	59 "	36 "
	Clover,............	39 "	56 "	5 "
Pot. & Soda Plants.	Indian Corn,........	71 "	6 "	18 "
	Turnips............	82 "	18 "	0 "
	Beets,..............	88 "	12 "	0 "
	Potatoes (tubers)....	85 "	14 "	0 "

After draining, no operation in the management of a farm requires so much forethought as the introduction of a proper rotation of crops. A number of rotations are given below, as *illustrations* of this important department of husbandry.

It is to be well observed, that no general rule can be given. The rotation depends in a great measure upon the character and composition of the soil; *also upon the markets.* A profitable practical rotation, often differs widely from a purely theoretical one. Many obvious reasons will immediately present themselves to the practical farmer for this distinction: such as climate, local or general diseases, accidental peculiarity in the physical character of the soil, &c. &c.

ROTATION COURSE, No. 1.

1st year, Wheat (Flint Plant).
2nd do. Oats with Clover (Flint Potash Plant).
3rd do. Clover for Hay (Lime Plant).
4th do. Grazed.
5th do. Grazed and broken up for Wheat.

ROTATION COURSE, No. 2.

1st year, Fallow.
2nd do. Wheat (Flint Plant).
3rd do. Peas (Lime Potash Plant).
4th do. Oats with Clover (Flint Potash Plant).
5th do. Clover (Lime Plant).

ROTATION COURSE, No. 3.

1st year, Beet or Turnips (Potash Plant).
2nd do. Wheat (Flint Plant).
3rd do. Red Clover (Lime Plant).
4th do. Wheat (Flint Plant).

ROTATION COURSE, No. 4.

1st year, Turnips, or Mangel Wurtzel (Potash Plants).
2nd do. Wheat with Red Clover (Flint Plant).
3rd do. Red Clover (Lime Plant).
4th do. Clover Hay (Lime Plant).
5th do. Wheat (Flint Plant).

We have seen that the food of vegetables consists of gases and solids, contained in air and the soil; also, that the gaseous food is extremely simple, and may be taken into the plant in two different ways: either by a discriminate absorption of carbonic acid from air, through the leaf, during the day-time; or by the indiscriminate rise of water, containing gases and solids in solution, through the extremities of the roots, to every portion of the plant. We cannot increase the amount of available food in air; we can, however, place abundance of all kinds within reach of the roots, in the form of manures.

[The continuous rise of the sap in plants, is due to the influence of two forces—that already described as capillary attraction; the other—the pressure of the atmosphere. A common candle-wick, or any bundle of cotton threads, if held over water so that the extremity of the wick or bundle of threads just touches its surface, will furnish us with the precise mode in which water rises through the extremities of the roots to every part of the plant. If no other force were called into operation but the attraction for water exerted by the sides of vessels, in the roots, stem and branches, the sap would be drawn up to the highest part of the plant, and then remain motionless, because there could be nothing above to draw it further up; yet during the warm and dry weather of spring, summer and autumn, the sap continually ascends, and sometimes with great force and velocity. Its uninterrupted and rapid current is mainly due to the pressure of the atmosphere, which is called into action by the vacuum resulting from the great evaporation which takes place from the leaves. The atmosphere, pressing upon the surface of the earth, forces the water contained in the soil through the roots to fill the empty spaces occasioned by evaporation. When the supply of water is insufficient, as in seasons of drought, or at the close of a very hot day, the leaves droop, and frequently wither. In wet weather, on the contrary, evaporation from the leaf ceases; the sap is consequently incapable of rising—it stagnates, loses its vitality and decays, and forms a fertile soil for the growth of fungi. (For the cause of the *descent* of sap from the leaves to the roots, see Note 9.) The general course of the sap in vegetables, is from the roots through the newer wood (the sap-wood), to an upper layer of veins in the leaf; it here loses much of its water by evaporation. It then passes from the upper layer of veins in the leaf to another layer immediately beneath them, through small capillary tubes. From the lower layer of veins in the leaf, it descends through the inner bark towards the roots again. During its descent, it lays on new wood, and strengthens the vessels of the old wood, by filling them up with solid matter.]

MANURES.—Whatever is added to the soil for the purpose of increasing its fertility, is termed a manure. The object of the farmer, in the use of manures, is either to place within the reach of vegetables, the substances they require to build up their structure, or to change the nature of the soil, that its fertility for cultivated plants may be increased. The most convenient mode of exhibiting the action of different manures, is to describe each separately, and state the effects they are capable of producing.

FARM-YARD MANURE is unquestionably the best kind for general purposes: it is easily accessible, and contains all the substances required by cultivated vegetables. The excrements of animals consist of a solid and fluid portion: the fluid portion is immeasurably richer in saline and mineral ingredients, and in ammonia, than the solid portion. In 100 lbs. of the solid excrements of the horse, there is generally to be found about

19 lbs. of vegetable matter,
3 do. saline and mineral ingredients,
78 do. water.
——
100 do.

The vegetable matter is slowly decomposed in the presence of air, and becomes converted into carbonic acid, water and ammonia—the atmospheric food of plants.

In a ton of fresh horse manure we find about

40 lbs. of Flint,
7 do. " Potash,
1$\frac{1}{2}$ do. " Soda,
$\frac{3}{4}$ do. " Iron,
3 do. " Lime,
2 do. " Magnesia,
4 do. " Phosphorus.
$\frac{3}{4}$ do. " Sulphur.

The older manure is, the less vegetable matter it contains, owing to its decomposition, and consequent escape, in the form of carbonic acid, water and ammonia; at the same time, the mineral ingredients will remain undiminished in quantity. It is evident, that a ton of old manure contains far more mineral substances than an equal weight of fresh manure; hence the reason why farmers prefer old manure for soils rich in vegetable matter.

Urine.—The fame of guano as a fertilizer is spread throughout the world. Many farmers would consider the possession of a few tons, as a surety for the success of future harvests. What is guano? The excrements of birds, composed of various saline and mineral ingredients, together with acids in combination with ammonia, of which latter substance guano contains from 7–17 per cent. Its beneficial effects are due to the presence of ammonia and phosphorus in a soluble state. Canadian farmers would not think of purchasing guano, even if a supply were at hand. The price of 40 to 60 dollars a ton, presents an insuperable objection to its use as a manure for agricultural purposes, especially when a substitute of almost equal value is to be found in the urine of the stables. The urine of a *full grown* cow, or horse, contains a quantity of soluble saline and mineral ingredients, exactly equal to the quantity of the same substances contained in the food consumed. In the solid excrements are found those ingredients which, as they passed through the body of the animal, resisted the action of the fluids with which they came in contact. This somewhat singular statement will appear perfectly credible, when we consider that a full grown horse, or cow, consumes food for years together without increasing in weight; that is to say, the mean or average weight of a milch cow, a working horse or ox, is the same throughout a period of many years. Certain constituents of the food assume the form of muscle, bone, fat and blood, supplying the place of an equal amount of worn out and useless materials which are discharged from the body in the urine. In 1000 lbs. weight of the urine of the horse, there are found about 45 lbs. of soluble saline and mineral ingredients, and 31 lbs. of a substance called urea, which, upon decomposition, resolves itself altogether, into carbonic acid and ammonia. In 1000 lbs. of the urine of a cow, there are found about 43 lbs. of saline and mineral ingredients, besides 18 lbs. of urea.

A horse voids, on an average, 3 lbs. of urine in a day. From November to March he will void about 450 lbs., containing 14 lbs. of urea and 20 lbs. of soluble solids, as much as is contained in 200 lbs. of guano.

A cow voids from 20 to 40 lbs. of urine in a day, according as she gives milk or not. If we take the lesser number, her urine will afford, during five months, 54 lbs. of urea, and 130 lbs. of soluble solids, as much as is contained in 500 lbs. of guano.

(The urine of a cow is valued, in Flanders, at 10 dollars a-year It contains 900 lbs. of solid matter, and this, estimated at the price of guano, is worth £4 sterling.—Johnston.)

A drain from the stable, or cow-house, to a barrel sunk in the earth, affords a convenient mode of collecting the urine, from which it may be carted, either in the liquid form to serve as a top-dressing, or thrown upon the dung-heap. Ammonia is a very volatile substance; that is, it rapidly separates itself from the urine, and becomes diffused throughout the atmosphere. Gypsum, charcoal, or partially burned clay, thrown into the barrel or upon the floor of the stable, will collect and fix this very volatile and useful body. A layer of clay, occasionally strewn over the dung-heap, is very effectual, not only in retarding decomposition, but also in fixing its gaseous products. If a dung-heap be exposed to the weather, too great care cannot be taken in collecting and preserving the drainage water, and applying it as far as possible to young growing crops: it contains a very large quantity of dissolved solids and gases, every particle of which, is capable of being taken into the structure of vegetables, increasing their growth, and facilitating their absorbtion and digestion of other gaseous and solid food, derived from the air and the soil.

Gypsum.—Gypsum (Plaster) is a very necessary article in the hands of the farmer: he may use it as a top-dressing, or strew it over the floor of the stable, or sprinkle it upon his dung-heap, or sow it with the seed. In all cases it serves two purposes:—1st, to fix ammonia; 2nd, to give sulphur and lime to his crops. Gypsum is especially useful on most soils, as a top-dressing for clover and grasses. The mode in which it exercises its beneficial influence, probably differs according as it is used for a top-dressing, or distributed with the seed. Its effects depend very much upon the time it is sown, when used as a top-dressing; and on the season, when planted with the seed—as with Indian corn or potatoes. It is most advantageously sown upon grasses and clover when the leaves are well developed, and before a shower of rain. It cannot be expected to produce much effect upon Indian corn or potatoes in a dry season, because of its great insolubility in water.

Lime.—Lime has been the successful agent in accelerating the restoration to fertility of numberless worn-out farms in Europe and America. It quickens the decomposition of clay, and forms with the potash, soda and flint of the clay—new compounds soluble in water. It opens and increases the porosity of stiff soils, depriving them of that tenacity and adhesiveness which is frequently an obstacle to working them, and a still more serious impediment to the expansion of the roots of young plants. Lime hastens and increases the effects of manures, and improves the sample of all kinds of cultivated crops, especially those grown for the sake of their seed. Many pernicious weeds are destroyed, and nutritious grasses improved, by the action of lime. It exerts a decided influence upon the duration of their growth, occasionally hastening their maturity by several days. Its effect upon soils containing a large quantity of vegetable matter is remarkable. Many acids are formed in the soil, during the decomposition of roots, manures, &c. These are often highly injurious to cultivated crops. Lime, however, neutralizes them, and occasionally forms nutritious compounds out of the unwholesome or poisonous ingredients. The quantity of lime to be applied to the acre is dependent upon the nature of the soil; from twenty to forty bushels are frequently required by retentive clay soils. The effect upon the amount of produce is often astonishing: numberless instances are recorded of a single application having raised the average from eighteen to twenty-eight bushels of wheat per acre. Virginia owes the restoration of her worn-out soil to a judicious application of burned lime. The effect of a good dose of lime is distinguishable for many years.

Leached Wood Ashes.—When wood is burned, many of its mineral and saline ingredients become insoluble in in water. This is especially the case with the lime, and compounds containing sulphur and phosphorus. The soluble portion of ashes consists almost altogether of potash and soda, which are dissolved out when water is filtered through them, in the process of making black salts or ley for the soap-boiler. In treating 100 lbs. of good ashes with water, from 20 to 40 lbs of soluble ingredients are conveyed away by the water, the remaining portion weighing from 60 to 80 lbs., forms an excellent manure, which may be used as a top-dressing, or mixed with the dung-heap.

Good husbandry implies the elevation of the standard of fertility and production, to the highest remunerative point, and its continuation there. A due attention to all the minutiæ of farming labour is far from being sufficient: continued success can never attend the most industrious farmer, if he neglect those precautions which experience and the science of agriculture suggest. It is a fact, which rests upon the most abundant and conclusive evidence, that no ordinary farm can continue for a succession of years to yield a fair return, if attention be not paid to rotation of crops, the application of manures, and at least surface draining. A very fair view of the condition of husbandry, on a farm, or in township, county or province, can be acquired by an inspection of the number of acres under different kinds of cultivated crops, exhibiting the ratio which grain crops bear to green crops, and these again to pasture and fallow.

NO FARM CAN CONTINUE TO PRODUCE GRAIN-GROWING CROPS ON A GREATER SURFACE THAN ONE-THIRD OF ITS CULTIVATED EXTENT, FOR MANY SUCCESSIVE YEARS, WITHOUT DIMINISHING SCALES OF PRODUCE: that is to say, a farm of fifty acres in the clear, and under cultivation, cannot sustain a larger amount of grain-growing crops than seventeen acres; or a farm of one hundred acres in the clear, and under cultivation, not more than thirty-four acres, producing at the same time high averages, and preserving their fertility undiminished.

The very indifferent and careless manner in which statistical returns of crops and produce are rendered by farmers, materially diminishes the value of what would be otherwise highly instructive and important information. We can deduce an approximate view only, of the condition of husbandry in the Province of Upper Canada, by examining the returns of 1848. Our comprehension of its most important features, will be greatly facilitated by instituting a comparison between the agricultural statistics of the whole province and some one county, say the County of York.

	County of York.			Upper Canada.
	1847.		1849.	1847.
Wheat	$15\frac{2}{5}$ bush.	per acre..	$19\frac{1}{5}$ bush...	$12\frac{7}{10}$ bush.
Barley	$19\frac{3}{5}$	do.	$18\frac{2}{5}$	18
Rye	$16\frac{2}{3}$	do.	15	12
Oats	$31\frac{2}{5}$	do.	$24\frac{2}{5}$	25
Peas	20	do.	16	21
Indian Corn	27	do.	27	22
Potatoes	82	do.	124	83

The crops appear to have been distributed in the following ratio:—

	COUNTY OF YORK.	UPPER CANADA.
Grain-growing crops (Flint Plants)	168,414 ac..	999,039 ac.
Green crops (Potash-Lime Plants)	79,115 do..	165,965 do.
Pasture	94,168 do..	766,768 do.
Fallow (suppose)	10,000 do..	100,000 do.

Let us imagine two farms, of 100 acres each, to be divided in the same ratio with respect to crops, and we obtain the following results :—

County of York, 1849.		Upper Canada, 1847.	
48 acres	Flint Plants	47 acres	Flint Plants.
22 do.	Potash-Lime Plants	$12\frac{1}{2}$ do.	Pot. lime do.
27 do.	Pasture	36 do.	Pasture.
3 do.	Fallow	$4\frac{1}{2}$ do.	Fallow.
100		100	

England, in 1835.	
21 acres	Flint Plants.
12 do.	Potash-Lime Plants.
58 do.	Meadow and Pasture.
9 do.	Fallow.
100	

The ratio which the grain-growing or flint crops bear to the whole hundred acres, are in,

County of York..	48 to 100	equal to one-half nearly.
Upper Canada ..	47 to 100	equal to one-half nearly.
England	21 to 100	equal to ONE-FIFTH nearly.

The high average of $19\frac{1}{5}$ bushels of wheat to the acre, in the County of York, for the year 1849, affords proof of the existence of much good land, and some good farming : the ratio which the grain-growing crops bear to the soil under cultivation, is equally indicative of a very large extent of bad farming.

The produce of the pastures in the same county is represented by the wool of 102,986 sheep, amounting to 321,441 lbs. The weight of the average fleece is a trifle over 3 lbs. ; that of the whole province being $2\frac{3}{4}$ lbs. Of cheese and butter, we find for the home markets or exportation 504,957 lbs. ; containing, with the wool, many thousand pounds of phosphorus, lime, magnesia and soda, which never find their way back to the soil again.

In the long-run, the exports of a country greatly affect the character of that system of husbandry which is productive of the greatest advantage. This is particularly the case in Canada, where the severity of the climate compels the farmer to house his cattle during many months of the winter season. The solid and fluid excrements are accumulated in one spot, and require care for their preservation and after disposition; a precaution with reference to the fertility of pasture lands, which is not needed where cattle can remain in the fields night and day for eleven months in the year, as in Holland, Belgium, and some parts of England and Ireland.

Under ordinary circumstances, the farmer takes soluble saline and mineral ingredients from his farm in the form of grain, hay, wool, butter, cheese, beef and pork, faster than atmospheric influences can create a fresh supply by the decomposition of the soil; and if he do not return a part so abstracted, in the form of manure, and give TIME, by a rotation of crops, for the solubility of the remaining part required, the fertility of his soil will decrease, and dimishing scales of produce will not fail to point out his error.

LECTURE II.

Compound substances found in Vegetables—Woody Fibre—Starch—Sugar—Oils and Fats—Nitrogen Compounds—Comparative table of compound substances found in Vegetables—Comparative value of different kinds of Manure—The digestive and respiratory processes of Animals—Purposes served by Food—Diseases of Vegetables produced by Fungals and Insects—Rust—Mildew—Smut—The Potato Disease—The Hessian Fly—The Wheat Fly—The Turnip Fly—The Wire-worm—Weeds of Agriculture—Chess—Canada Thistle—Other Weeds—Conclusion.

The results of modern investigations into the chemistry of vegetables and animals, furnish us with most striking and comprehensive views of the relationship existing between them. The products of vegetable life are capable of being converted by the wonderful process of digestion, into bone, sinew, flesh, and blood. In other words, the gases of the air and the mineral ingredients of the soil, assume the form and substance of sentient and moving beings, through the instrumentality of vegetables, and those vital energies with which animals are endued by the Creator. The purposes served in the animal economy, by the compound bodies, such as starch, oil &c., which are found to exist in vegetables, constitute a subject of deeply interesting enquiry: and in no other field of scientific research, have the labours of chemists been rewarded with such beautiful and surprising results.

Among the innumerable products of vegetable organization, not more than nine or ten are of direct interest to the farmer, with respect to the feeding and improvement of stock. These are susceptible of division into two classes, according to the elementary substances of which they are composed.

Thus, we have

FIRST CLASS.

Woody Fibre, Starch, Gum, Sugar, Oils.	Composed of Oxygen, Hydrogen, and Carbon.

SECOND CLASS.

Compounds containing Nitrogen.

[The presence of Nitrogen constitutes the great difference between the two classes of vegetable substances. It will be found to exercise the most astonishing influence upon the purposes served by them in the animal economy, when used as food. It will be seen that the nutritious parts of vegetables—those which go to form bone and muscle, are distinguished by the presence of Nitrogen. Particular attention is due to this substance in treating of the feeding of animals.]

The most remarkable circumstance connected with some of these bodies, is their perfect identity in composition. Thus we have the bodies, starch, gum and sugar, which differ so widely in external characters, in their appearance, their taste, their odour, composed of precisely the same materials, united together in the same proportions.

[In 162 lbs. of sugar, starch or gum, there are exactly 72 lbs. of carbon, 80 lbs. of oxygen, and 10 lbs. of hydrogen. In 34 lbs. of oil of turpentine, or oil of citron,—two liquids differing widely in their properties, there are contained 30 lbs. of carbon and 4 lbs. of hydrogen. The difference in properties is due to the arrangement of the particles of which they are composed. We may suppose the mode in which this arrangement differs to be as follows:—In one body, say starch, one unit of hydrogen may be associated with 6 of carbon and 8 of oxygen, to form one unit of starch. In sugar, we may imagine 2 units of hydrogen, to be combined with 12 units of carbon and 16 of oxygen, to form one unit of sugar.]

The various properties of these bodies, being dependent upon the mode in which their particles are arranged together, afford us an excellent illustration of the beautiful simplicity and admirable contrivance exhibited in all of Nature's works.

Woody Fibre.—Woody Fibre forms nearly the whole mass of forest trees: and about one-half of the stalk of grasses and straw of grain-growing crops. Its quantity in succulent roots, such as the turnip, beet, carrot, potato &c.,

is very small, being rarely more than from two to four per cent. Woody Fibre is formed of carbon and the elements of water, it decomposes (decays) slowly, when exposed to moisture or air; it is then converted into two compounds, carbonic acid and vegetable mould; when the last named substance is exposed in a moist state to air, it absorbs oxygen with rapidity, and gives off an equal quantity of carbonic acid. It is thus that the decay of vegetable mould, affords an abundant supply of food to young plants. When woody fibre is in contact with potash, soda or magnesia, its decay is much accelerated; when surrounded or impregnated with an acid substance, as strong vinegar, or weak spirit of salt, decomposition is very much retarded. The decay of woody fibre is a question of some interest to farmers and builders; great expense is occasionally incurred in renewing sleepers, sills, gate posts, fences, &c., which have decayed immediately above the soil, where they come into contact with moisture, the potash, soda, and lime of the soil, and the oxygen of the air. If charred by burning, or coated with pitch, coal tar, &c., the decomposition of the wood will be greatly retarded. An excellent mode of preserving wood is extensively used at present in England: it consists in placing the wood to be cured in a common boiler, which is then nearly filled with tar oil, and the air pumped out by means of exhausting air pumps: a fresh supply of oil is then forced into the boiler, by hydraulic pressure, and the whole allowed to remain for some hours. The effect produced is such as to render any kind of wood perfectly insensible to exposure, and free from the attacks of insects; iron bolts will not rust when driven into it. The expense of preparing the wood in England, is from 13 to 18 shillings per load. Pure woody fibre is found in the forms of the fibres of cotton, hemp, flax, and thus constitutes a most important material for the manufacture of textile fabrics. Bleaching consists in the destruction of oils, resins and other matters which are associated with the woody fibre and discolour it. Woody fibre may be converted into gum, sugar or starch, all of which bodies are identical in composition, and may be said to consist of carbon and water. By a process requiring a little nicety in manipulation, it is changed in toa very explosive compound, known as gun cotton.

STARCH.—This very important vegetable substance, is found in the seed and roots of all cultivated plants.

Wheat Flour contains from....	50 to 75	per cent.
Barley Flour.................	65 to 70	do.
Rice.........................	80 to 85	do.
Indian Corn..................	75 to 80	do.
Potatoes	13 to 15	do.

It is found also in the bark of many trees, especially in that of the willow and pine; by a simple process it can be obtained from shorts in large quantities: the shorts must be mixed with water, and allowed to remain in the vessel until the whole mass ferments and becomes sour, for the purpose of removing the gluten, which would otherwise retard the separation of the starch. One of the first results of the germination of seeds is the conversion of their starch into sugar: which, being composed of carbon, oxygen, and hydrogen, serves as the food of the young plant for the formation of its first roots and leaves. The process of germination is imitated in malting. The starch of the grain is converted into sugar, which, in the manufacture of beer breaks up into two new substances, carbonic acid, rising in bubbles (froth) and alcohol.

[Starch is completely insoluble in pure cold water; the roots of the maple, beech, &c., contain a substance (disastase) which possesses the property of rendering starch soluble in water. During the autumnal months, starch is deposited in the wood through which the sap ascends. When spring commences, water is forced up through the roots and dissolves a portion of the substance (disastase) just alluded to, this again dissolves the starch the water meets with in its course, and converts it into sugar. The process is similar to that which takes place during the malting of barley.]

SUGAR.—Sugar is found in the juices of many vegetables, particularly the sugar cane, beet roots, carrot, birch, maple, &c.

[Upwards of five hundred millions of pounds of cane sugar were imported into the United Kingdom during the year 1838. In the same period, France and Belgium manufactured from the beet root not less than one hundred and forty-five millions of pounds. From the maple, in the year 1848, Canada obtained four millions of pounds. The quantity brought into the markets of the world—of sugar obtained from different vegetables, amounted twelve years ago, to the enormous number of 1653 millions of pounds.]

In the manufacture of beet root sugar, the first operation consists in washing the roots, which is usually done by a rotatory movement upon a grating, in a shallow trough containing water; they are next submitted to the grinding process of a rasp, consisting of a number of small saws, attached to a drum, having a rapid and uniform movement; when thus reduced to pulp, the semi-liquid mass is collected in bags and submitted to pressure; the juice is then conveyed to the boiler; before boiling it should be mixed with common slacked lime, in the ratio of 1 lb. of lime to 88 gallons of juice; after boiling for a short time it should be again filtered through blanket stuff, and then concentrated by boiling, in the usual manner of making maple sugar; if a fine quality is required, after the second boiling has been carried on for some,—until the juice attains the consistency of thin syrup,—it is to be filtered through a layer of bone black or finely powdered charcoal, and then concentrated by boiling until crystalization takes place.

Oils and Fats.—More or less of these substances are found in all vegetables; they consist of a solid and fluid portion, which can be separated, by first subjecting the oils or fats to cold, for the purpose of hardening them, and afterwards submitting them to pressure between folds of linen. The oil is absorbed by the linen, and may be obtained pure, by immersion in hot water. The solid portions of many oils and fats are identical in composition, thus, the solid ingredient of olive oil, butter, the goose, and of man are alike.

There are contained in 100 lbs. of

White Mustard Seed........	36 lbs. of Oil.
Black Mustard Seed.........	15 lbs. do.
Sunflower...................	15 lbs. do.
Beech Nut.................	15–17 lbs. do.

NITROGEN COMPOUNDS.—A large number of compounds containing nitrogen are found in vegetables. Many of these are identical in composition with the various parts of the animal frame. It is a remarkable fact that a substance, exactly like perfectly clean muscle, is found in the juices and seeds of vegetables, together with two other ingredients; one similar to the white of an egg, the other to the curd of milk. They all contain sulphur, in the proportion of one part of sulphur for every twenty-five parts of nitrogen. It is thus that the muscular matter of animals, and the chief portion of their blood (dissolved muscular matter) is furnished by vegetables. A VEGETABLE WHICH DOES NOT CONTAIN ANY NITROGEN INGREDIENTS, CANNOT ASSIST IN ADDING ONE PARTICLE OF MUSCLE TO THE ANIMAL FEEDING UPON IT.

It will be hereafter shown that a daily waste takes place in the animal body, that worn-out and dead particles of flesh are removed in the urine. The places of these useless and rejected particles, can only be supplied by the nitrogen compounds contained in their food; it therefore follows, that diet which does not contain nitrogen compounds can not serve as nutriment. An animal feeding on such diet would soon become wasted, feeble, and diseased. "A horse may be kept alive by feeding it with Potatoes, a food containing a very small quantity of nitrogen; but life thus supported is a gradual starvation: the animal increases neither in size nor strength, and sinks under every exertion."—Liebig.

Subjoined is a table prepared by Professor Johnston, to illustrate the average composition and production of nutritious matter per acre, for each of the usually cultivated crops. This table will be of interest to farmers, for the purpose of exhibiting the relative value of their crops, with reference to the feeding of cattle.

	Bush.	lbs.	Woody Fibre.	Sugar Starch.	Nitrog. Comp.	Oils or Fats.	Saline Ingred.
			lbs.	lbs.	lbs.	lbs.	lbs.
Wheat....	25	1,500	225	825	150 to 220	30 to 60	30
Oats.....	40	1,700	240	850	230	95	60
Barley....	35	1,800	270	1,080	216	45	36
Indian Corn	30	1,800	270	900	216	90 to 170	27
Peas......	25	1,600	130	800	380	45	45
Potatoes...	6 tons.	13,500	675	1,620	300	45	120
Turnips...	20 "	45,000	1,350	4,500	540	130	400
Carrots....	25 "	56,000	1,680	5,600	840	200	560
Mead. Hay.	1½ "	3,400	1,020	1,360	340	70 to 170	220
Clover Hay.	2 "	4,500	1,120	1,800	420	135 to 225	400
Drumhead Cabbage	20 "	45,000	..	..	1,500	..	..

It has been shown by the most exact experiments, that such substances as starch, gum, sugar and oil, which do not contain nitrogen, cannot support animal life for any length of time. All substances in cultivated crops containing nitrogen, are capable of assuming the form of animal flesh and blood, when used as food. The nutritious powers of vegetables are therefore dependent upon the amount of nitrogen they contain. It is to be observed, that the term "nutritious powers" refers to the capability of the vegetable to supply the materials of flesh, blood, and bone, for young animals, or for the daily waste which takes place in adults, and has no allusion whatever to fat, which is either provided by the oil or fat of the food, or obtained from the decomposition of starch, sugar and woody fibre.

In the above table we find, that 1,500 lbs. (25 bushels) of wheat contain from 150 to 220 lbs. of nitrogen compounds. If we take the lower calculation, we find that 100 lbs. contain 10 lbs. of nitrogen compounds. It appears also that 45,000 lbs. (20 tons) of turnips will contain 540 lbs. of the same important substances. 100 lbs. of turnips will contain therefore $1\frac{1}{5}$ lbs. of nutritive matter. 100 lbs. of wheat are consequently more than eight times as valuable, for the purpose of giving bone, muscle and blood to animals, as 100 lbs. of turnips.

[In the juices of vegetables, nutritious substances, together with saline matter, are found in a dissolved state; when, by the slow process of evaporation, the water is expelled, these dissolved substances assume the solid form, they are then less easily acted upon by the organs of digestion. It is thus found in practice, that green fodder is more nutritious than in the dry state—in the green state than when made into hay. A French chemist found that 9 lbs. of green lucern were quite equal in foddering sheep to $3\frac{8}{10}$ of the same forage made into hay; while he at the same time ascertained, that 9 lbs of green lucern would not on an average yield more than $2\frac{1}{50}$ lbs. of hay. These facts must therefore be borne in mind, in considering the following table by Bouissangault.]

Comparative Table of the Value of different kinds of Food for Cattle, Meadow Hay being taken as a standard.

Name of Vegetable.	Water in 1,000 lbs.	Nitrogen in 100 lbs. of the Article, not dried.	Theoretical Value.
		lbs.	
Ordinary Meadow Hay	110	11	1000
Ditto, fine quality	140	13	980
Red Clover Hay, 2d year's gr.	101	15	750
Red Clover, cut in flower, do.	750	6	3110
Wheat Straw	200	3	4000
Oat Straw	210	3	3800
Pea Straw	85	17	640
Vetches cut in flower, and dried into Hay	110	11	1010
Drum Cabbage	923	3	4110
Field Beet or Mangel Wurtzel	878	2	5480
Carrots	876	3	3820
Jerusalem Artichokes	792	$3\frac{1}{3}$	3482
Potatoes	659	$3\frac{2}{3}$	3190
White Peas (dry)	86	38	270
Oats	208	17	680
Field Beans	79	51	230

Example.—In 1000 lbs. of meadow hay, there are contained 11 lbs. of nitrogen, and 110 lbs. of water. Its nutritious value as food is considered equal to 1000, which is taken as the standard of measurement. Red clover hay, second years' growth, contains in 1000 lbs. 15 lbs. of nitrogen and 101 lbs. of water. Its value as food is represented by 750; that is to say, 750 lbs. of red clover hay, second years' growth, afford as much nourishment as 1000 of meadow hay. Again:—3190 lbs. of potatoes, containing 659 lbs. of water and $3\frac{2}{3}$ of nitrogen, in 1000 lbs. of the root, are as nutritious as 1000 lbs. of meadow hay. Or if we feed an animal with 270 lbs. of peas, it will obtain as much nourishment from them, as from 3820 lbs. of carrots, or from 680 lbs. of oats, as from 3800 lbs. of oat straw, or from 1000 lbs. of meadow hay, as from 5480 lbs. of turnips.

Let us suppose, for the sake of illustration, that the stock of hay runs short, and that instead of giving 20 lbs. to his horses per diem, the farmer can only afford 10. The problem he has to solve is this:—What quantity of turnips, carrots, potatoes, mangel wurtzel, oats, or oat-straw, will afford a substitute for 10 lbs. of hay, and keep the teams in good working condition. The table informs us that 10 lbs. of good hay, are as nutritious as 67 lbs. of turnips, 38 lbs. of carrots, 31 lbs. of potatoes, 54 lbs. of field beet, 6 lbs. of oats, or 38 lbs. of oat-straw.

Now, there are many circumstances which interfere with the practical value of this table in its present condition. It contains within itself, however, the elements of much useful information. A working horse requires more food than one which is idle; a cow giving milk, more than one that is dry. Nutritious diet, packed in a comparatively small space, is essential to a working horse—otherwise he would not have time to consume his food. But a kind of diet, occupying a *very small space*, would not fill the stomach of the animal; he would consequently feel hungry, although enough had been eaten to supply all the purposes of nutrition. Boussingault says, that a horse of the ordinary size, requires from 26 to 33 lbs. of solid food, and the same quantity of water, in the twenty-four hours. If fed with oil-cake, he would consume as much nutritious matter in

6½ lbs. as in 33 lbs. of hay, but his stomach would be only partly filled, and he would still feel hungry. If fed upon wheat straw, he must consume 165 lbs. to give him the requisite nourishment—a quantity too large to be eaten in a day.

The usual allowance for a horse, for the 24 hours, on the farm of the last named gentleman, consists of—

No. 1.—Hay	22 lbs.	
Straw	5½ "	
Oats	7½ "	(1¾ gallon.)

With this ration, the teams are kept in excellent condition.

No. 2.—Hay	10 lbs.	
Straw	12 "	
Oats	12 "	(2⅘ gallon.)

Let the price of hay be £2 per ton, of straw, 28s. do., and of oats, 1s. 6d. per bush., reckoning 34 lbs. to the bushel, the cost of these rations, No. 1 and 2, will be as follows:—

No. 1.		No. 2.	
Hay	4.7146d.	Hay	2.143d.
Oats	3.79	Oats	6.35
Straw	.820	Straw	1.8
Total	9.3246d.		10.293d.
			9.3246
Difference in favour of No. 1			.9684
			Nearly one penny.

All of the following rations were found beneficial.—"The animals did their work well, and were kept in good condition":—

Hay	11 lbs.	
Straw	5½ "	
Oats	7½ "	(1¾ gal.)
Jerusalem Artichokes	31 "	

Hay	11 lbs.	
Straw	5½ "	
Oats	7½ "	(1¾ gal.)
Mangel Wurtzel	44 "	

Hay	11 lbs.	
Straw	5½ "	
Oats	7½ "	(1¾ gal.)
Carrots	40 "	

Farmers are in the habit of attributing a stimulating property to oats, as an article of food. It is true that they contain a very large quantity of nitrogen compounds, packed in a small space. They are, therefore, highly useful where the time taken in their consumption is a matter of consequence. 12 lbs. of good hay contain as much nourishment as 1¾ gallons (7½ lbs.) of oats, but the animal requires a far longer time to consume it, its bulk being much greater. Under all circumstances, a mixed food is advantageous,—it renders the animal less liable to disease than when fed on one article of dry food alone.

MILCH KINE.—The influence exercised by different kinds of diet, upon horned cattle, is almost incredible. It is perfectly useless to attempt keeping good stock, without due attention to food. In the long run of years, with attention and care, stock always pay. We frequently hear complaints to the contrary—whence, however, do they arise? From a complete misapprehension of the use of stock upon a farm. It is perfectly true that at a distance from markets, the sale of beef and mutton, butter and cheese, do not remunerate the farmer. Let us add to these items, MANURE, and see how the balance-sheet stands. A farmer who manures occasionally and sparingly, we will suppose, has 20 acres in fall wheat: he is accustomed to reap 17 bushels to the acre. By good manuring, we may reasonably expect that he will obtain 25 bushels—an increase on his whole crop of 160 bushels, due to manure alone. The value of 40 bushels will pay for labour and time expended in the operation. There remains a clear profit of 120 bushels. To beef, mutton, wool, cheese, butter, milk, he must not only add 120 bushels of wheat, but also the improved condition of his land, before he can estimate the gain or loss, on a fair proportion of stock. Where the value of manure is so little known, that barns and stables are occasionally shifted, as the most convenient mode of getting rid of the *nuisance*,—where fields are cropped for many years, without receiving one particle of that which is wasting near them,—it will appear utterly incomprehensible, that cattle greatly assist in improving the fertility of a farm. Happily, such deplorable ignorance is not very frequently to be met with in Upper Canada. With respect to farm-yard manure, it is nevertheless unquestionable that its value, especially of the liquid portion, is by no means generally appreciated.

Let us remember the principle of husbandry introduced on page 42, THAT NO FARM CAN CONTINUE TO PRODUCE GRAIN-GROWING CROPS, ON A SURFACE GREATER THAN ONE-THIRD OF ITS CULTIVATED EXTENT, FOR MANY SUCCESSIVE YEARS, WITHOUT DIMINISHING SCALES OF PRODUCE. A farmer must have a rotation of crops in order to preserve the fertility of his soil. He must have manure, or recourse to fallow and wheat rotation. If the above principle is once recognized, the great advantages resulting from the preservation of a constant ratio between stock and arable land, on an arable farm, will become easily apparent. The severity of the climate in Canada, and the markets, establish the value of that ratio. It is unquestionable that a much larger amount of stock can be kept upon a farm in the United Kingdom than in this country. Experience and circumstances alone, can enable the skilful farmer to determine whether the five shift, the four shift, or three shift rotation is most remunerative. The rotation he adopts will enable him to discover the amount of stock he can sustain, bearing in mind the importance of having a sufficiency of manure for his grain-growing fields.

Few animals grow so rapidly as the calf. The average daily increase, until they are weaned, is considerably over

2 lbs. They feed upon the perfection of food, upon milk, which contains in itself all the substances required to build up the animal frame.

In 100 lbs. of cow's milk there are found:

87 lbs. of water,
$\frac{3}{5}$ do. saline ingredients, (bone-earth, &c.)
$4\frac{3}{4}$ do. sugar of milk,
$3\frac{1}{6}$ Oil and fat, (butter)
$4\frac{1}{2}$ Nitrogen compounds, (curd, flesh)

[The curd is a nitrogen compound, dissolved in the water of the milk. Its solubility is due to the presence of soda. If an acid be introduced into the milk, it seizes upon the soda and forms a new compound. The curd is insoluble in water destitute of free soda, it therefore immediately assumes the solid state when an acid substance is poured into the milk. This operation goes on in warm weather, in the following manner:—Milk contains sugar, which is converted by a new arrangement of its particles into an acid, called milk acid or lactic acid. The acid forms a union with the soda. The curd, deprived of soda, is no longer soluble in water, it consequently separates in a solid form. The change of milk sugar into milk acid, is effected artificially by the introduction of a substance in a state of decomposition—as rennet or the stomach of a calf. The decomposition which is going on in the rennet, communicates an impulse to the particles of the milk sugar, which re-arrange themselves under its influence, and assume the form and properties of milk acid.]

Every thing connected with the feeding of cattle is of importance. They should receive their food with great regularity, and be driven to water at least twice in the day. In the winter time care should be taken to free the water trough from ice, since when the water is very cold, cattle drink as little as possible; their supply of milk is consequently reduced. Water, at the temperature of that which comes from a well 25 to 30 feet in depth, is the most favourable for cattle. A good milk cow will, if well fed with a mixed ration of hay or cut straw, and some roots thrown down whole before her, yield milk for 260 to 300 days, and give on an average 10 pints of milk in a day. They must be housed during the winter months. A cruel and most unprofitable system prevails largely in remote townships, of permitting the cattle to be exposed to the inclemency of the weather, with an indifferent diet of straw and what they can browse during the whole winter. Their milk necessarily fails, and when spring returns, they are found in such a reduced and deplorable condition, that many weeks, and even months, elapse before they regain their strength and habit. The conditions for fattening an animal are satisfied if it has repose, warmth, cleanliness, and regular feeding. A mixed diet of dry and succulent food, such as hay and roots, in the winter months, and good clover, or excellent pasturage during the summer.

The quantity of fresh manure produced by the horse and cow, is nearly double the quantity of solid food they consume. Thus, if a horse or cow eat 100 lbs. of hay, the weight of the fresh manure produced will be about 160 lbs. This great addition is due to the water which the animal drinks. A farmer can always estimate the number of tons of manure he will have, from the quantity of food consumed by his stock. If he has 20 tons of hay, and 50 tons of roots, at the commencement of the winter, there will be about 90 tons of manure when the food is consumed. If the whole quantity could be eaten by a very large number of cattle in one day, not less than 120 tons of manure would be produced. But we must suppose that a farmer's stock, *during the winter*, consume 70 tons of mixed diet, at the commencement of spring he will have the same amount of manure, for the average age of the manure is 10 weeks, (supposing the winter to be 5 months long,) and in that time much would decompose and pass off, in the form of vapour of water and gases, without a continued frost retarded its decay. 20 tons of fresh manure will have lost more than half its weight before it is fully rotten. The value of different kinds of manure are here introduced in a tabular form. They will serve to direct the attention of the farmer to those which are easily accessible. Good farm yard manure is taken as the standard of comparison, and its value represented by 100:—

Farm-yard manure	100 lbs.
Solid cow dung	125
Solid horse dung	73
Cow urine	91
Horse urine	16
Sheep dung	36
Pigeon dung	5
Fresh bones	$7\frac{1}{2}$

[*Bousingault.*

From the above table, we learn that 100 lbs. of good farm-yard manure may be expected to produce as much effect as 125 lbs. of cow dung, 73 lbs. of horse dung, 91 lbs. of cow urine, 16 lbs. of horse urine, &c.

The purposes served by the constituents of food in the animal economy, constitute a subject of very interesting inquiry, and of some practical value to farmers in the management of stock. A brief view of the digestive and respiratory processes will enable us to trace the changes which take place in articles of food, before they minister to the well-being of animals. The digestive organs of the horse and the ox differ in many respects—the successive steps, and the final result obtained, are the same in both instances. The food is introduced into the mouth, and having been well masticated, is conveyed into the stomach, where it is subjected to the dissolving influence of the gastric juice. It passes from the stomach into a large intestine. Into this intestine two liquids, called bile and pancreatic juice, are being continually poured from the liver, and pancreas or sweetbread. The food is now resolved into two portions, one of which is absorbed by a number of small vessels, which terminate in the inner coating of the intestines, the other is transmitted onward, and as residual matter, is carried on through the intestine, and finally given off as excrements; the fluid absorbed by the small vessels, is collected in a receptacle, situated behind the stomach, and near the back bone in man. From this receptacle, a tube or duct, conveys the prepared food to a vein, situated at the back of the neck. It here mixes with the blood and is taken directly to the heart, in the impure form of venous blood; from the heart it is forced through a system of veins to the lungs, where it comes in contact with the oxygen of the air drawn into the lungs during the process of respiration. A considerable portion is now given off in the form of carbonic acid and vapour of water through the mouth; and what remains, constituting purified or arterial blood, goes back to the heart to be propelled to every portion of the body, supplying nutriment where it is required. In ruminating animals, we find four stomachs, all connected continuously with the gullet or meat pipe. It is in the last of these stomachs that the process of digestion is carried on. The first is called the paunch, and prepares the food for rumination, by softening it. The food then passes into the second stomach, where it is rolled into pellets for the purpose of being returned to the mouth for remastication, (the cud). From the mouth it is conveyed directly into the third stomach, where it suffers a second softening process, after which it is propelled into the fourth stomach, where digestion is completed, as before described. The time which elapses before food is returned to suffer remastication, is about 16 hours: very hard and coarse diet, requires a much longer period for preparation in the paunch and second stomach. In breathing, the air is taken through the wind-pipe into the lungs, which are somewhat similar in structure to a very fine sponge, enclosed in a bag. The sides of vast numbers of the small cells of which the lungs are composed, consist chiefly of blood vessels, so that when impure or venous blood is forced from the heart to the lungs, it is diffused by means of the small blood vessels over a very large surface, and at the same time exposed to the air which is contained in the lungs, the sides of the blood vessels being so thin and porous, that although they are capable of retaining liquid blood, they cannot oppose the passage of oxygen and carbonic acid. When an inspiration takes place the lungs are filled with air, a portion of its oxygen passes through the sides of the minute blood vessels surrounding the air cells, and part unites with the carbon and hydrogen of the venous or impure blood, which is given off again in the form of carbonic acid and water, the other portion is absorbed by the blood, and conveyed to every part of the system. We here observe a great distinction between the respiration of plants and animals. VEGETABLES ABSORB CARBONIC ACID, AND DECOMPOSE IT IN THEIR LUNGS—THE LEAVES; ASSIMILATING THE CARBON AND EMITTING THE OXYGEN; ANIMALS ABSORB OXYGEN, AND COMPOSE CARBONIC AND WATER IN THEIR LUNGS, GIVING THEM OFF WITH EACH EXPIRATION. The wisdom and beauty of this arrangement will be appreciated, upon an examination of the effects which would be produced upon air, were the results of animal respiration to remain unchanged. One cubic foot of carbonic acid in ten cubic feet of air, renders it unfit for the support of animal life, a far less quantity is highly prejudicial and oppressive. The quantity of Carbon consumed daily by the inhabitants of Canada (780,000) amounts at the lowest average to 200,000lbs., producing 700,000 lbs. of carbonic acid; other breathing animals, stock, &c., consume about five times as much. In one year by respiration alone, the enormous quantity of 438,000,000 lbs. of solid carbon is converted into carbonic acid and given off into the air. This supply of carbon is obtained from the food consumed, and serves to support animal heat. The annual production of carbonic acid by the inhabitants of the world is estimated at 156,000 tons, formed from 42,000,000 tons of carbon. If to this we add that which is produced by other breathing animals, by the decay of vegetable matter, and by burning bodies, we arrive at numbers absolutely overwhelming. Vegetables feed upon this result of animal respiration; they purify the air of a noxious gas, which is to them, as necessary for their growth, as the oxygen, which they return in equal volume to the carbonic acid absorbed, is essential to the preservation and well-being of animals. When oxygen combines with carbon, or with hydrogen, heat is liberated, it is thus, that the union which takes place in the lungs, gives rise to animal heat, preserving a uniform temperature of the blood under all circumstances of health. A horse consumes daily about four pounds of carbon, that is to say, about four pounds of carbon are daily obtained from the food and dissolved in the blood, these, combining with oxygen during respiration, go off in the form of carbonic acid. About ten ounces are consumed in the lungs of a man daily, the carbon must necssarily be supplied from the food; the starch, gum, woody fibre, sugar and oil, or fat, furnish this carbon to herbivorous animals, the fat and flesh of their food, to carnivorous animals, and their own fat and flesh, to starving animals.

We are now enabled to trace with greater accuracy, the purposes served by food in animals.

An ox, we will suppose, consumes a quantity of food, equal in nutritious qualities to 40lbs. of hay ; 40lbs of hay are composed of—

Water	4	lbs.
Woody Fibre	12	"
Sugar and Starch	$15\frac{3}{4}$	"
Nitrogen Compounds	4	"
Oil or fat	$1\frac{1}{4}$	"
Saline Ingredients	$2\frac{1}{2}$	"
	40	lbs.

The water and undissolved substances are ejected in the excrements ; the dissolved sugar, starch and woody fibre serve to support respiration, they are given off in the form of carbonic acid and vapour of water, by the mouth and skin, (perspiration). In a state of repose, a portion of the starch or sugar is converted into fat. The nitrogen compounds are employed to form additional muscle or flesh. The worn-out particles of flesh are given off from the body in the urine. The oils and fat of the food serve two purposes,—1st. That of supporting respiration and the temperature of the blood—2nd. That of assuming the form of animal fat. The saline ingredients replace the daily loss which takes place in the bones and juices of the flesh. The rejected substances being found in the urine.

[The production and maintenance of animal heat, involves many interesting considerations with reference to food. The temperature of the blood in man is very uniform. In a state of health and repose, it is the same, whether tested in the cold of an Arctic winter, or in the sultry climate of the torrid zone. Two processes combine to produce this result —respiration and perspiration. The temperature of the blood in birds, is from 104 to 107 degrees; of serpents, from 50 to 60 degrees; of fishes, from 2 to 4 degrees above that of the medium in which they live. In all cases the production of heat is connected with the absorbtion of oxygen, and its union with carbon and hydrogen. Heat exists in two states—free or sensible, and hidden or latent. Sensible heat is that amount of temperature which can be measured by a thermometer; latent heat is that which is intimately associated or combined with the particles of bodies in which it resides. A change in form frequently causes bodies to give out latent heat, or to absorb it from surrounding bodies. When air is compressed into a small space, it gives out a large quantity of heat. When cannon are bored, the boring instrument frequently loses its temper by the great heat evolved. A blacksmith hammering cold iron for a few successive minutes can make it red-hot. All these facts furnish us with illustrations of the conversion of latent heat into sensible heat. If equal quantities of cold water and sulphuric acid be mixed together, the temperature rises suddenly above that of boiling water. When salt and snow are mixed together, the temperature of the mixture falls thirty degrees below the freezing point. In the former case, heat is evolved; in the latter, it is absorbed. The former illustrates the mode in which heat is liberated, when during the process of respiration, the oxygen of air combines with the carbon and hydrogen of the food dissolved in the blood. The latter exhibits the manner in which heat is absorbed from the body, when its moisture goes off in the form of insensible perspiration. When an animal is suffering from fever, the temperature of the blood rises, because the superabundant heat evolved is not absorbed in the change of water into the vapour of water. It has been remarked, that fat, starch, gum, sugar and woody fibre, supply the carbon and hydrogen for the purposes of respiration. It is evident that a large supply of carbon and hydrogen is required by the inhabitants of a frigid climate, where the quantity of oxygen taken into the lungs and absorbed by the blood during each respiration, is probably greater than in the temperate or torrid zones. We discover a beautiful connection between the quantity of oxygen absorbed and the nature of the food consumed. The Esquimaux devour large quantities of blubber and oil, substances consisting almost altogether of carbon and hydrogen. The natural heat of the body is sustained by such diet. The lumber-men on the Ottawa complain of the leanness of the pork raised on the banks of the river. The fat pork of Ohio finds a profitable market for the winter consumption of men, exposed to all the severities of a climate where the thermometer falls twenty degrees below zero. According to Thomson, the blood in an adult weighs about 26 lbs. avoirdupois; it circulates through the body in $3\frac{3}{50}$ minutes. During each inspiration, 16 cubic inches of air enter the lungs, and $\frac{17}{40}$, or nearly one-half of a pound of blood is exposed to its action. During every inspiration, $\frac{13}{20}$, or rather more than one-half of a cubic inch of oxygen is absorbed by the blood; and $4\frac{3}{4}$ cubic inches of oxygen, combining with carbon or hydrogen in the animal system, evolve one degree of heat; during every inspiration, therefore, the oxygen absorbed, evolves about one-sixth of a degree of heat, so that one degree of heat is evolved in six inspirations. Hence, in a day of twenty-four hours, the heat evolved by the union of the oxygen of air with the carbon and hydrogen of the food, would heat a middle-sized man thirty-three degrees. Hybernating animals breathe very slowly, the heat of the body is sustained by the union of the oxygen of the atmosphere with the carbon and hydrogen of their fat.]

Diseases of Vegetables (Fungals, Insects.)—Cultivated crops in Canada are liable to many diseases produced by microscopic vegetables and the depredations of insects. Among the former, the most prevalent and destructive, are

Rust, Mildew, and Smut. Among the latter, the Hessian-fly, the Wheat-fly, the Turnip-fly, and the Wire-worm.

Rust is a fungus (a minute vegetable) of exceedingly rapid growth, and fruitful character. It is not confined to cultivated grain-growing crops. No vegetable, indeed, is free from liability to its attacks. The general appearance of Rust on wheat is entirely dependent on the state of the atmosphere. During the spring, summer, autumnal, and even winter months, the air contains multitudes of the germs or seeds of small microscopic plants, which are carried about by winds, and begin to grow whenever they alight upon a suitable soil. The descent of rain or mist brings down myriads of these seeds, invisible to the naked eye, which fall upon the leaves and stalks, or pass into the system of plants with the water which enters at the roots. If the plants are in a state of perfect health, the vitality (life) of the sap prevents their germination and growth; if the motion of the sap is retarded for any length of time, the pores on the leaves and stem become filled with stagnated and consequently lifeless sap. When the rust seeds reach these pores, they germinate, throwing out a number of stalks; at the end of each is a ball, which rapidly ripens, and bursting, scatters around a dust composed of particles so extremely minute, that they can only be seen by a powerful microscope, when a number are aggregated together. Each little particle is capable, under proper circumstances, of producing a new plant. There are many species of Rust plants; the most common and destructive are the orange and the red. When found to a large extent on grain-growing crops, they absorb the nourishment of the plants, and frequently destroy the most promising crops.

It has been already remarked that the *continuous flow* of the sap in vegetables is mainly due to the pressure of the atmosphere, caused by the evaporation of the water of the sap from the surfaces of the leaves and stalks. If evaporation is suppressed, by any external causes, the sap ceases to flow; it accumulates by capillary attraction in the vessels of the plant, and stagnates at the surfaces of the stalk and leaves, affording a suitable soil for the growth of microscopic fungi.

[The small mouths or pores through which evaporation of moisture takes place, are found in all parts of healthy plants except the roots. When seen through a microscope, they present the appearance of small slits, communicating with the vessels of the bark or rind. Their number on some species of vegetables is very great. On 1 square inch of the leaf of the common clove pink, there are no less than 38,500 on the upper and under surfaces; on the upper surface of the vine leaf, 13,600, and on the under side of the common lilac, there are 160,000 to the square inch. In a very moist state of the atmosphere, the minute vessels connected with these pores become filled with sap, the opening or pore is distended, but evaporation does not take place, because the moist air can receive no more vapour of water. It is easy to understand how these minute vessels, with distended mouths, filled with motionless sap, form a secure and favourable resting place for the seeds of microscopic fungi.]

Now, the evaporation from the surfaces of vegetables ceases when the air is loaded with moisture, as after rain, in fogs, and in damp weather generally. Air, it will be remembered, can only contain a certain quantity of moisture, dependent upon its temperature. When there is but little difference between the warmth of the air in the day and night times, as in damp sultry weather in June, July, and August, the quantity of moisture suspended in air, is nearly uniform, and evaporation ceases as long as that uniformity continues. Rust is most frequent upon rank and luxuriant crops, as might be expected from their great evaporating surface.

Since the prevalence of rust is entirely dependent upon the condition of the atmosphere, and the more or less luxuriant growth of the vegetable, the attention of the farmer must be directed to two circumstances, in order to lessen the effects liable to be produced by these destructive fungi. 1st. To the period of the season in which the occurrence of damp and sultry weather is to be looked for. 2nd. To the habit of the plant. If Rust strike the plant before the seed begins to form, the most disastrous effects may be produced: if after the seed has been formed, yet before it is ripe, little apprehension need be entertained for the safety of the crop. Now, experience shows, that in the climate of Canada the condition of the atmosphere is very seldom such as to favour the germination of the seed of Rust, before the last week in June; if, therefore, at that period, the wheat plant is so far advanced as to be beyond the influence of Rust, as regards the formation of the grain, the danger is provided for.

[Wheat was gristed at Merrickville, on the Rideau Canal, on the 19th of July, in 1849.]

The precautions to be taken against Rust, happily constitute a necessary step in good husbandry—they are DRAINING and LIMING; both operations accelerate the growth and ripening of wheat, and the strength of the straw. There is no question that by a judicious introduction of these artifices, the destructive effects of Rust on wheat, would be very much diminished, if not in many seasons entirely prevented.

MILDEW is occasioned by microscopic fungi, which attacks all kinds of vegetables, under circumstances favourable for their production. The stalk of wheat seems to be particularly liable to their depredations. Numerous species are known to infest the grain-growing crops. Their growth is dependent upon the moist state of the atmosphere, and like the germs of Rust, their seeds are constantly floating about the atmosphere, and driven to and fro by winds. The stalks and leaves of healthy plants are provided with a coating of vegetable wax, which prevents the rain from wetting their surfaces. We discover this wax (bloom) on peaches, grapes, plums, the stalks of wheat, oats, rye, on the leaves of the nasturtium, &c. As long as the wax remains, there is little danger of Mildew, or Rust, but in moist weather, with a loaded atmosphere, or under other circumstances unfavourable to the production of a healthy plant, wax is not formed. The remedy against the attacks of these fungi is the production of a healthy plant—the remedy for Rust, liming and draining—offers the only available means to the Canadian farmer.

[It will be observed that in healthy plants, the dew is found in the morning in pearly drops, either upon the surface of the leaf or round about its edges. But dew falls equally upon every portion of the upper surface of a leaf, on cloudless nights; it can not wet the leaves of healthy plants on account of the delicate covering of vegetable wax. The small particles of moisture attract each other, and form a drop. When the leaf or stalk is wetted all over, the formation of wax has not recently taken place, and the plant is liable to be struck with Mildew, whose minute seeds find on the wetted surface of the stalk, a soil favourable for their growth. If dry weather succeeds, no disastrous results need be apprehended: in a continuance of moist and heavy weather, much harm may be done.]

Smut.—Smut presents us with another form in which minute parasitical plants prey upon vegetables of larger growth. It is usually found to affect grains of wheat. There are two varieties of this noxious fungus. One not discoverable until the husk is opened, when it appears in the form of a black powder, having a very disagreeable and characteristic smell. The other variety shows itself on the outside of the grain. Farmers possess a remedy for both, which consists in steeping the seed in some liquid which will destroy the vegetative powers of the fungal seeds. These seeds are so minute, that a grain of smutty wheat will infect the contents of a bushel; and wheat placed in bags which have at one time held smutty wheat, will certainly be infected. The best sample for seed should always be steeped before sowing. Various liquids are selected for that purpose—stale urine, brine, and blue vitriol dissolved in water. The last is perhaps the best. Five pounds of blue vitriol (sulphate of copper) are dissolved in ten gallons of boiling water. When the solution cools, three bushels of wheat may soak in it for six hours, the light floating grains being skimmed off. The wheat should then be drained through baskets or sieves, and dried by being rolled in gypsum or lime. The same solution of blue vitriol will serve to steep twenty bushels of wheat, and effectually provide against the appearance of smut.

POTATO DISEASE.—The universal prevalence of this malady seems to imply the existence of a universal agent in producing it. The results of the investigations of many chemists, agriculturists, and botanists, point towards one primary cause, which is to be found in the state of the atmosphere. There is still much to be learned respecting the processes of vegetable life, yet from what is already known, the potato disease appears to be occasioned by a temporary incapacity of the atmosphere to receive the water of evaporation from the leaves, when loaded with moisture.

As in the case of rust on wheat, the vessels of the potato plant are then filled with stagnant sap, which is rapidly thrown into a state of decomposition, and affords a suitable soil for the growth of fungi taken into its system by the water entering at the roots. Diseased potatoes, although the root may appear to be perfectly sound on the outside, have frequently, when cut open, exhibited a cavity filled with minute vegetable forms. The disease is greatly accelerated by small insects, which habitually feed upon vegetables, such as the far-famed Aphis Vastator, &c.

All root crops are subject to the same disease as the potato, and there is no reason to suppose that the malady is of recent origin. Its existence has been noticed as long as the potato has been used as an article of food. A cure, founded upon the principle of reducing the evaporating surface of the leaves, has been adopted in Germany with success. It consists in mowing off the top leaves when the plant has attained the height of seven or eight inches, and repeating the operation every five weeks, until the tubers ripen.

THE HESSIAN FLY.—(Cecidomyia Destructor.)—The Hessian fly derives its name from the manner in which it was supposed to have been introduced into this Continent. Popular opinion ascribed its introduction to the straw brought over by the Hessian troops, in the year 1776. The fly appears in the fall; the female then lays her eggs, from one to eight in number, between the leaf and stalk of the wheat plant, immediately above the first joint. The worms eat into the stem, and frequently cause it to break. They winter in the torpid state, and subsist during the spring months upon the sap of the plant. They then pass into the chrysalis state, and in autumn assume the form of the fly.

It seems to be well established that a strong wheat plant will support without material injury to itself, the growth of two or three worms, while a weak and sickly plant would fail under the increased tax upon its energies. It is the frequent custom, where the Hessian fly prevails, to grow wheat after wheat. In ploughing the stubble into the ground, and then by a second ploughing preparing it for the seed, the chrysalis is first buried, and afterwards turned up to the surface, or sufficiently near the surface, to permit the chrysalis to assume the fly state during the growth of the next crop of fall wheat. The females deposit their eggs upon the leaves of the young plants, which growing upon a soil exhausted by many succeeding crops, can not sustain the assaults of the newly-hatched worm. If a proper system of rotation of crops were introduced upon a farm where the Hessian fly prevails, the act of ploughing very early in the autumn, and allowing the land to remain in the rough state until the spring operations for green crops commenced, would bury the chrysalis for a length of time, and effectually destroy it. Burning the stubble is also found advantageous in checking the ravages of this insect: the crysalis being lodged immediately above the first joint, is consumed by the fire passing over the field.

The Hessian fly is very local in its habits: very wet weather after harvest destroys multitudes of these insects in their chrysalis state.

The Wheat Fly.—(Cecidomyia Tritici.)—A small orange-coloured fly, which lays its eggs in the ear of wheat during the last week of June or the first week of July. The eggs are hatched in six or seven days; the insect exists in the worm state for about three weeks, feeding upon the substance of the grain; it then assumes the form of a minute chrysalis, after which it passes into that of the fly.

The great object of the farmer in providing against the depredations of the wheat-fly, is to have his wheat so far advanced, that when the fly appears, and lays its eggs, the newly-hatched worms may not be able to penetrate the husk. The means which suggest themselves for effecting so desirable a result are to favour the early maturity of the plant by liming, draining, and a careful selection of seed.

Wire-Worm.—(Elater Striatus.)—The grub of a beetle, which may be seen in localities where the wire-worm abounds, on the leaves of wheat, &c. The beetle folds its legs on the approach of an enemy, and falls to the ground. The wire-worm feeds on the under-ground stems of young plants, and frequently destroys them.

Buckwheat is highly recommended as destructive to the wire-worm. A clean summer fallow is also instrumental in starving them out. It is very probable that the ammoniacal liquor of the gas works would be found a very useful agent in destroying these pests.

Turnip-Fly.—(Haltica Nemorum.)—This insect (beetle) is one of the most formidable enemies to the turnip crop. It appears and continues during the whole of spring and summer. Danger is only to be apprehended in the early stages of the turnip's growth, before the third and fourth leaves have been developed. Every endeavour should be made to force on the young plants, by means of manure. The liquid portion of stable manure is most favourable to their rapid growth. To drive away the fly, many farmers sprinkle their young turnip crops with soot; urine and the ammoniacal liquor of the gas works would be found equally efficient in preserving the plant from its depredations. The turnip-fly is seldom seen during the day time; it then occupies the under surface of the leaf. When the sun has set, the fly may be found in abundance on the upper surface. The sense of smell of this beetle is remarkably acute; it can discern the odour of the turnip—its favourite food—at great distances. Hence the reason why the odour of ammonia—the characteristic odour of soot, urine, and the ammoniacal liquor of the gas works, is so repugnant to the delicate sense of smell possessed by this minute and destructive beetle.

Weeds of Agriculture.—Chess (Bromus Secalinus).—The appearance of this common and troublesome weed is the source of more dispute than any subject which comes within the province of the agriculturist to investigate. The most erroneous impressions respecting its origin, prevail among farmers throughout the whole of Canada and the neighbouring States. Popular opinion ascribes to what is termed diseased wheat, or winter-killed wheat, the property of transmutation into chess; and this opinion is promulgated and sustained in the most positive manner, upon the deceptive and erring evidence of individual observation, without the slightest reference to the botanical distinctions which mark wheat and chess.

Chess is a very hardy and fruitful kind of grass, called in Britain the soft brome grass. Its seeds possess the power of lying dormant in the soil for many years, without losing their vitality. There are many modes of accounting for the presence of this weed among wheat and other crops. It is sown with the wheat, or its seeds, lying dormant in the soil, have their vitality called into action when the soil is ploughed up and exposed to light, air, and warmth, or it is conveyed by floods, or carried by winds, or carted on to the soil with manure.

The reason why chess *surplants* wheat, and grows with luxuriance, is to be found in bad cultivation. On undrained soils, and especially on those parts where water is permitted to lodge, the wheat plant is winter-killed or thrown out; chess, being a more hardy vegetable than wheat, survives the winter, and produces a most abundant crop of seed.

Good surface draining, the use of clean seed, and a rotation of crops, will soon extirpate chess, and effectually remove the impression of an imaginary transmutation. We might, with as much reason suppose that the oak was capable of changing into the pine, the pine into the birch, the beech and maple into the poplar, the grass of the prairies into white clover. All these apparent transmutations do take place, but the reason is to be found in the death of one kind of vegetable preparing the soil for, or permitting the growth of, those vegetables whose seeds are lying dormant in the soil.

Canada Thistle—(Cnicus Arvensis.)—Throughout the length and breadth of Canada this weed may be met with in the greatest abundance. During the present year certainly not less than one-eighth of the wheat crop of the country has been "thrust out of life" by the Canada thistle. No one travelling in the months of July and August on the shores of lake Ontario, from Colborne to Pickering, could have failed to observe here and there a field of wheat almost free from the presence of this noxious weed, and yet surrounded by wheat fields on neigbouring farms, purple with their blossoms, presenting a forcible illustration of the good effect of careful farming. The only sure "cure" for Canada thistle is a rotation of crops in which clover forms a prominent element: two years of a good clover lay will destroy the Canada thistle root and branch.

Many other weeds call for the care and perseverance of the farmer in their destruction,—none, however, appear to prevail so generally as chess and the Canada thistle: careful cultivation, with draining, an occasional summer fallow, and a judicious rotation of crops, will check the production of these enemies to successful agriculture.

From the foregoing brief exposition of the principles of Agricultural Science, it will appear, that husbandry in all its branches affords a wide and interesting field for intelligent observation. The most insignificant operation of practical agriculture presents material for reflection and minute enquiry. The farmer may engage in a routine of manual labour, established by experience, and requiring the mere exertion of muscle, with results satisfactory to himself; he may also associate with bodily exertion the higher exercise of his mental gifts, promising greater remuneration and better acknowledgement of his privileges as an intelligent member of society.

Let us, in concluding, take a cursory view of the several conditions of vegetable life and health, which unite with the operations of husbandry in establishing the results of which the agriculturist is in quest. He can exercise no control whatever over the air plants and animals breathe; and yet many of the most terrible visitations he fears are dependent upon the condition of air. Upon its state, rests the appearance of Rust, Mildew and many parasitical insects, all of which lead most effectually to destroy the anticipated results of his industry. The condition of perfect humidity in a warm atmosphere, at certain seasons of the year, will suffice to cause his crops to be clothed with the most destructive of microscopic plants. This humid state may occur in March, April, September, &c., without being the cause of prejudicial results, if it happen in May or June great danger is to be apprehended. From observation, we learn, that coarse luxuriant wheat grown on rich moist soils is very liable to be struck with Rust or Mildew. This is often the case on fertile river bottoms—on the rich bottoms of the Thames &c. It is also remarked that in late seasons Rust is most destructive; that the time when it strikes the plant is generally in the month of June—if late in that month, the straw only suffers, if early, straw and grain are both lost. Now, as the humidity of the atmosphere is beyond the control of man, he must adapt his labours to the circumstances of the climate. He must endeavour to have an early crop—with a thin, strong, flinty stem. It has been before remarked, that the means for ensuring the ripening of wheat, from two to three weeks earlier than the average period, are to be found in draining and liming, both operations, besides ensuring early maturity, improve the sample and strengthen the straw.

The agriculturist is dependent upon other meteorological phenomena, with the due occurrence of which, the health of his crops is most intimately associated; upon rain and temperature. He has occasionally to deplore the occurrence of dry weather in the spring, and of wet weather in the harvest time. The seasons of the present year were particularly distinguished by these drawbacks. Those artifices which are commended by experience and suggested by the science of agriculture, present him with the only means capable of lessening the amount of evil flowing from such casualties. On drained soils, the roots of cultivated crops descend deep, and find in dry weather a supply of moisture. Their early maturity saves them from that destruction which is always more or less to be lamented in wet harvests. In backward and wet seasons, the grain crops lose many days of warm spring weather on undrained soils, before they commence growing. The heat of the sun must first drive off the superfluous water, which is lodged in every hollow and depression, although it may not be visible at a superficial view. Cold rains invariably check the growth of vegetables, and a cold watery bottom (pan) to the soil in which the roots repose, can never be expected to favour the growth of a healthy plant. The appearance of yellow leaves upon wheat in the spring, is the result of disease, and may be produced by excess of moisture or by excess of drought. It has been already shown, under the head of draining, that that operation greatly increases the temperature of the soil, by allowing warm air to circulate through its pores. Vegetables do not necessarily thrive when the surface of the soil is exposed to a great increase of temperature; it is when heat descends to the roots that they feel its invigorating influence. The warm sun of April and May cannot produce the same effects in vegetable growth, on a heavy clay soil, or even on a vegetable mould, as upon one of a light, sandy, porous character.

We have seen that uncultivated vegetables derive a very large portion of their substance from the admixtures of air, carbonic acid and ammonia. Cultivated crops obtain these elements of food, not only from air and decaying vegetable matter, but also from manures. That department of husbandry which involves the production, preservation and application of manure, necessarily calls for the careful attention of the agriculturist. Chemistry and experience both set their mark upon farm-yard manure, as constituting the most useful means of improving the fertility of the soil; and of farm-yard manure, the liquid portion, the urine of animals, is unquestionably the most valuable. The solution of mineral ingredients in water, previously to their entrance into the roots and system of vegetables, directs particular observation to the composition of soils, and the properties possessed by their component parts. It appears that the same kind of vegetable growing for a succession of years upon the same soil, abstracts certain soluble mineral ingredients, faster than the great agents, heat, air and moisture, can create a supply from the vast store which exists in an insoluble state in the soil. Hence the vegetable cultivated under such circumstances, becomes deteriorated in quality, and approaches nearer and nearer to that primitive, wild state, in which its kind existed before cultivation produced the wondrous development of its organs which fit it for the food of man. (Witness the wild potato, the apple, the plum, wild rice, wild wheat, wild oats, &c.) To avoid this deterioration, experience and agricultural chemistry point to rotation of crops, fallowing under certain circumstances, farm-yard manure, mineral manures, as lime, wood-ashes, gypsum, &c.

The growth of weeds among cultivated crops, is an increasing and serious evil. Nourishment which, in their absence, would find its way into farming produce, feeds them into a luxuriant and fruitful habit, which at once suppresses the growth, diminishes the yield, and impairs the sample of those vegetables for whose benefit all the artifices of husbandry are expressly practiced. The use of clean seed, the practice of clean cultivation, of draining, and of rotation of crops, can alone eradicate those hurtful vegetables, which, from past neglect, seem now to be successfully struggling to gain exclusive possession of many fertile tracts of country.

The cold of winter is sometimes so severe, that the wheat plant loses its vitality, even on drained soils. This happens when there is a deficiency of snow. A covering of snow prevents radiation of heat from the earth into the clear expanse above. The temperature of two plants, one exposed to air on a fine clear cold night, the other covered with a very loose coating of straw, differs by many degrees. A few loads of long dung or litter, strewed over the wheat in the month of December, will retard radiation, and prevent the temperature of wheat plants from sinking so low during severe winter nights, as to endanger their vitality. Lastly, the economy of a farm cannot in general be preserved without a due proportion of stock for the production of manure, and the preservation of a judicious rotation of crops.

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APPENDIX.

Note 1.—A simple substance is one from which nothing else but itself can be obtained—as lead, iron, gold, oxygen, carbon, &c. Sugar, water, milk, are compound bodies: they consist of two or more simple substances combined together. Whenever a compound body is broken up into other bodies, or into the simple substances of which it is formed, it is said to be decomposed. Thus when water is decomposed, it is converted into oxygen and hydrogen gases. When wood is burnt, it is almost entirely converted into carbonic acid, water, and ammonia.

Note 2.—*Nitrogen.* Place a short candle in a basin, pour some lime water (see note 6) round about the candle, until it rises within an inch of the wick. Take an empty bottle, with a wide mouth, light the candle, and carefully put the inverted bottle over it, until it dips half an inch below the surface of the water. In a few seconds the candle will go out, having consumed all the oxygen. The water will rise in the bottle when it cools. Cork under water, and shake the bottle. The carbonic acid produced by the burning candle, will combine with dissolved lime, and render the water milk-white. Nitrogen, nearly pure, remains in the form of an invisible gas.

Note 3.—*Oxygen.*—Fill a glass with water: invert it, and let it rest upon a saucer filled with the same fluid. (This may be effected in a common bucket, by putting both glass and saucer under water; having filled the glass, let it rest on the saucer, and lift both out.) Place some green leaves under the glass and expose them to the direct light of the sun; bubbles of gas will soon be seen to form upon the surfaces of the leaves. The gas is pure oxygen. It is obtained from the decomposition of carbonic acid by the leaves, under the influence of the sun's rays. The bubbles will cease to be formed when all the carbonic acid contained in the leaves and water is decomposed. Put some bits of chalk or limestone and a few drops of vinegar into the water; the operation will be renewed; carbonic acid being liberated from the chalk.

NOTE 4.—*Ammonia.*—Put a small quantity of spirit of hartshorn (ammonia) into a spoon, and hold it over the candle; at the same time, heat some spirit of salt (muriatic acid) in another spoon, and blow the fumes of ammonia in the direction of the spoon containing spirit of salt. A dense white cloud will be formed immediately. Muriatic acid gas combines with ammonia, and forms the solid sal-ammoniac.

Pour some spirit of salt into a spoon, warm it over the candle or fire, and take it into a close stable: white fumes of sal-ammoniac will be formed. The ammonia in the stable proceeds from decomposing urine.

NOTE 5.—*Carbonic Acid.*—Pour strong vinegar upon some pieces of chalk or limestone. Violent effervescence will be observed, caused by the liberation of carbonic acid from its union with the lime of the chalk or limestone. If the chalk is at the bottom of a deep glass vessel, heavy carbonic acid will displace the air, and a lighted piece of paper being introduced, will be immediately extinguished.

NOTE 6.—*Lime Water.*—Pour rain water on newly-burned lime, decant the clear liquid, and breathe into it through a straw or tobacco pipe. The water contains dissolved lime, the carbonic acid of the breath combines with the lime, and forms chalk, (carbonate of lime, pure limestone) which renders the water milk-white. Continue breathing; after a time it will become clear again. The water absorbs carbonic acid as the air from the lungs passes through it, but water absorbing carbonic acid acquires the power of dissolving chalk, or pure limestone, hence the clearness of the liquid. The presence of lime at the bottom of many kitchen utensils, arises from the heat to which they are exposed driving off the carbonic acid from the water, which is thus rendered incapable of retaining lime in solution.

NOTE 7.—If a pint of water be converted into steam by heat, and the steam thus formed passed through five pints of water, it will raise the whole to the boiling point. From which it is inferred that the steam contains five times as much heat as the boiling water from which it was formed. When water evaporates slowly, it absorbs heat from surrounding bodies—hence evaporation always produces cold.

NOTE 8.—*Hydrogen.*—Introduce some iron turnings or bits of zinc into a small bottle. Make a hole through the cork and insert the stem of a tobacco pipe, so that it fits accurately. Mix some oil of vitriol (sulphuric acid) and water; about one part of the former to four of the latter. Pour the mixture on the metal, cork the bottle tight with the prepared cork, and after the lapse of a minute apply a light to the extremity of the pipe. The gas issuing from it will take fire. It is hydrogen, and is obtained by the decomposition of the water. Take a *small* dry phial and collect some of the gas by holding it over the pipe; bring it immediately to the flame of a candle—an explosion will take place and water be formed, the phial becoming dim with water.

NOTE 9.—*Descent of the sap in Vegetables.*—If two fluids of different densities be separated by an animal membrane, after a short time, portions of either fluid will pass through the membrane, and mix with the other fluid; this operation will go on until their densities are uniform. If, therefore, we take a long glass tube, either straight or bent, tie round one extremity a portion of the intestine of an ox, sheep, or pig, and pour a quantity of brine into the open end of the tube; then plunge the whole into a short tube or glass, containing a small quantity of pure water, we shall observe the fluid in the long tube rise many inches above its former height; the water in the glass vessel will diminish, but taste strongly of salt. The operation will go on until the fluid in both vessels attains the same density. Here we have an example of what takes place in the vegetable fabric. The porous substance of the leaves and bark, represents the porous animal membrane,—the glass of water, the sap in the newer wood and the water in the soil,—the long tube in which the fluid rises, the stalks, branches, and bark of trees, commencing in the roots, going on through the newer wood, the leaves, and the inner bark, to the roots again. The brine represents the dense sap produced by the evaporation from the leaves and bark. It is evident that the operation of diffusion is continually going on after the water has entered at the roots; it goes on more rapidly as the sap ascends; its rapidity is greatly increased after the sap has been thickened by the great evaporation from the surfaces of the leaves. The pressure of the atmosphere, owing to this evaporation, together with capillary attraction, keeps up a constant supply of pure water, derived from the soil.

NOTE 10.—*Water from leaves of Vegetables.*—Enclose a leaf, while still attached to the tree, in a dry bottle; close the mouth with wax, and cover the wax with paper, to prevent the sun from melting it. After a few hours the bottle will be dim with moisture. After a few days it will be half full of water.

NOTE 11.—*Porosity of Bodies—Condensation of air within their pores.*—Put a piece of dry pine charcoal into a wide-mouthed bottle; fill the bottle with cold water, and immerse it with the mouth downwards in a pan or other vessel; place on a stove or fire. Care must be taken in immersing the bottle that no air gets into it—(see Note 3). As the water warms observe the effect. The air contained within the pores of the charcoal will expand, and issue from them in the form of a minute stream of bubbles, which, collecting at the top of the bottle, will show what a large quantity was contained within the pores of the charcoal. When the charcoal is taken out of the bottle, after cooling, it will be found much heavier than before, having absorbed water in place of air. It is thus that soils, when well drained, contain large quantities of air; when undrained their pores are filled with stagnant water, prejudicial to the growth of the roots of vegetables.

NOTE 12.—Shade a leaf, or an entire plant with a common flower-pot: it will become white. In the absence of light, the leaves cannot decompose the carbonic acid they absorb, consequently no colouring matter is formed. The brilliant colours of different kinds of roses are produced by a constitutional inability to decompose carbonic acid. If the petals of the flowers decomposed as much as the leaves, they would be green. When potatoes are exposed to the light of the sun, the rind absorbs carbonic acid—decomposes it, and forms green colouring matter.

NOTE 13.—Procure from a chemist a solution of nitrate of silver, nitrate of baryta, oxalate of ammonia, and spirit of hartshorn or ammonia. Pour pure rain water upon a small portion of any soil, stir well, and let it remain over night; filter the water through clean filtering paper, and pour a small quantity of the clear liquid into six or eight glasses. Introduce a drop of nitrate of silver; if a white cloudy appearance is produced, the presence of salt is most probably indicated, especially if the white appearance turns purple in the sun. If a few drops of nitrate of baryta produce a precipitate which is not dissolved when a little oil of vitriol is introduced into the water, it contains sulphur, most probably in the form of sulphate of lime or gypsum. When ammonia is introduced and causes a reddish-brown precipitate, the water contains iron. When oxalate of ammonia is mixed with the water, and produces a cloudy appearance, it contains lime, which after a while will fall to the bottom, in the form of oxalate of lime.—(Oxalic acid is the cause of the agreeable acidity in rhubarb.) If effervescence takes place upon the addition of a little vinegar or oil of vitriol, the water contains carbonic acid. If a bulky precipitate appears when ammonia is poured into the water, a quantity of spirit of salt must be added, until the precipitate vanishes, and ammonia again introduced; if no precipitate appears, the last observed consisted of magnesia, coloured probably by iron. If the precipitate does appear in the same quantity as before, the water contains alumina—(the body which gives rise to the tenacity of clay, but which is not always found to enter into the composition of vegetables or animals)—if less in quantity, that which has vanished contains magnesia, and what remains consists chiefly of alumina. These experiments will serve to indicate the presence of the substances mentioned, in a soluble state in the soil, or in water of wells, springs, rivers, &c. They do not in themselves possess any other value. The *correct* analysis of a soil is a very tedious and difficult operation. None but a practiced chemist should attempt it, in the hope of obtaining reliable, and consequently useful, results. The nature of the necessary processes may be seen in the appendix to Johnston's large work on Agricultural Chemistry.

British Military Ration in Canada.

OFFICERS' HORSES, DRAUGHT HORSES, AND OXEN.

9 pounds of Oats, Barley, Indian Corn, or 14 pounds Bran.
16 ditto of Hay.
6 ditto of Straw.

When Oats or Bran cannot be had,

32 pounds of Hay.
6 ditto of Straw.

CAVALRY AND ARTILLERY.

10 pounds of Oats.
12 ditto of Hay.
8 ditto of Straw.

☞ The writer of these pages has received numerous applications from school-teachers and farmers, for a list of the apparatus and materials which are required in illustrating a brief course of lectures on Agricultural Chemistry, or individual study of the science. It has been, at the same time, urged, that considerable difficulty occurs in parts of the country, remote from large towns, in obtaining the necessary materials. An arrangement has, therefore, been entered into with Mr. F. Richardson, Practical Chemist, King Street, Toronto, for furnishing boxes of apparatus and materials. Each box will be provided with a short description of the mode in which a large number of experiments can be made, not only illustrative of the science of Agricultural Chemistry, but also of some of the most important phenomena of Heat.

A Box of Apparatus can be obtained upon application to Mr. F. Richardson, after the 1st of January, 1851. The price will probably not exceed six dollars.

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ERRATA.

Page 14, last line—for Note 6, read Note 7.
" " for Note 7, read Note 8.
Page 17, last line—for Note 8, read Note 10.
Page 29, line 7—for "before it is cooled much, frozen soil," read "before it is cooled to 30°, much frozen soil."
Page 35, line 8—for "Flint Potash Plant," read Flint-Potash Plant."
Page 35, line 15—for "Lime Potash Plant," read "Lime-Potash Plant."
" "—for Flint Potash Plant," read "Flint-Potash Plant."
Page 52, line 36—after "Field Beans," &c., read "Swedish Turnips, 91—$1\frac{7}{10}$—6700.
Page 53, line 13—for "turnips," read "field beet."
Page 61, line 31—for "156,000 tons," read "156,000,000."