disposed to say, what bosh! Let us figure fairly on both fertilizers and dung, and without attempting to say which is better. Only say how much of either we can use profitably. Not that the same fertility is taken up by the crop from the dung as from the fertilizer, but the *principle* is the same for the *available* plant food for each.

In farming, success or failure, in the long run depends on the man, and we might as well know it. If the blame attached to failure of crops was laid where it belonged, and if every farmer carried the record of his failures on his back, as the Japanese laborer does his name, we would readily build up a prosperous agriculture and a highly intelligent community. We shall find crops failing this year, and the failure laid on the fertilizer, because the fertilizer cannot speak for itself, and cannot say, "You put me in the wrong place, applied me in the wrong way, and used no judgment with your crop." Let the farmer, however, who would be progressive, question himself, and in realizing his shortcomings, prepare a foundation for a future prosperity. He who recognizes his own failings, is in the way of correcting, and so long as we are in the right path, we may reasonably indulge in hopes of arriving at the promised goal.

Carbon—Hydrogen—Oxygen.

Simple words these, but of how much import to us and our surroundings. In their combinations, the most diverse productions which concern us in our living. Carbon or charcoal, hydrogen and oxygen, or water. The union of these form compounds differing from each other in looks, taste, smell, and chemical reactions. Thus, acetic acid is composed of 12 atoms of carbon, and 24 atoms of hydrogen and 12 atoms of oxygen, or charcoal and water; not, strictly speaking, charcoal and water, but that a rearrangement of these atoms would represent charcoal and water. Again, sugar is composed of these very same elements in different proportions, thus: carbon, 12 atoms; hydrogen, 22 atoms; oxygen, 11 atoms. These facts may be represented as below:

C, Carbon.
H, Hydrogen.
O, Oxygen.
$H^2 O$, Water.
$C_{12} H_{24} O_{12}$, Acetic Acid or Grape Sugar.
$C_{12} H_{22} O_{11}$, Cane Sugar.

Still more wonderful, we have fruit or grape sugar, composed of identically the same atoms as acetic acid—the sour principle of vinegar.

What more different, apparently, than starch and wood? Yet cellulose, or pure woody fiber, and starch are similarly composed of C 12 H 20 O 10. Yet the one we use as food for our bodies, the other but as a waste product, as in sawdust. Yet the fats are composed in turn of exactly the same elements as is starch and woody fiber. From these same elements are also formed chlorophyl, which is the green principle of plants; also mucilages and gums; one class of fibers, as linen, jute, and ultimately paper; oxalic acid, so poisonous, if taken into the stomach; and citric acid so grateful in lemonade.

Let us group some of these wonders in a table, reminding the reader to read the letters as indicating the substances, C for Carbon, H for Hydrogen, O for Oxygen, and the figures the proportional parts which are combined.

Acetic Acid, C_{12}, H_{24}, O_{12}.
Oxalic Acid, C_2, H_6, O_5.
Citric Acid, C_6, H_8, O_7.
Woody Fiber. C_{12}, H_{20}, O_{10}.
Starch, C_{12}, H_{20}, O_{10}.
Mucilage, C_{12}, H_{20}. O_{10}.
Fruit Sugar, C_{12}, H_{20}, O_{12}.
Cane Sugar, C_{12}, H_{22}, O_{11}.
Gum Arabic, C_{12}, H_{22}, O_{11}.
Olein (Fat), C_{57}, H_{104}, O_6.

We can thus form an idea of the wonderful resources of nature in forming useful compounds; and this list is but a very small one compared to what might be offered. Under the same composition, many products which affect us differently, given but a slight difference in the quantity, and innumerable new compounds.

Add another element to these, nitrogen, and we have flesh, albumen of egg, casein and the whole tribe of albuminoids, which enter into our foods and the structure of our bodies. From these elements, or a portion of them, are formed the ammonia and the nitric acid, so essential to our crops.

Truly a wonderful thing this nature within which we exist, and of which we form a part; and a wonderful science this chemistry which unfolds to us these secrets of nature.

FERTILIZER LAW.—Mr. N. G. Vreeland, of Metuchen, N. J., sends us a copy of a law recently passed by the legislature of New Jersey, to control the sale of fertilizers, valued at above $10.00 per ton. It provides:

"That commercial manures or fertilizers sold or kept for sale in the State of New Jersey, shall have affixed to every bag, barrel or parcel thereof, which may contain fifty pounds or upwards, a special printed name or trade mark, by which the same may be known or designated, with the name and place of business of the manufacturer or importer, together with a true specification of the guaranteed percentages of phosphoric acid soluble in water, total phosphoric acid, nitrogen and potash contained in the contents of the package, and also the quantity of the fertilizer contained in said package, and the date of its manufacture or importation."

It also provides for the payment to prosecuting purchasers by the dealer or manufacturer violating the law, the sum of $5.00 for every 100 pounds bearing a false or untruthful stamp. But the law does not provide for a State Inspector, which seems to us to be essential to the efficient working of the law, and which is the case in Massachusetts, where the law is of incalculable benefit to farmers, and is working smoothly. Let us be thankful, however, for every such step in the right direction.

Botany and Horticulture.

Darwin's New Book.*

BY PROF. W. J. BEAL.

It seems to be the general opinion of all who are prepared and competent to judge, that Mr. Darwin has produced a most wonderful book,—as I believe, one which has not been excelled in importance to the farmer by any work in this or in any age.

It is not easy reading, even to the botanist who is most familiar with the subjects treated. The author has recorded in a book of about 500 pages, a vast number of experiments and observations made, and in many cases often repeated, during a period of ten or twelve years. He has crossed the flowers, sowed the seeds and measured the heights of the plants, weighed or counted the seeds and capsules, often two or three times for many years, of several specimens of plants belonging to 57 species, of 52 different genera of 30 families. These are natives of very different parts of the world. He has made a book choke-full of information, valuable to the gardener and farmer, yet, in the words of the *Gardener's Chronicle*, "It is certain that these practical results will be a long time filtering into the minds of those who will eventually profit most by them." If the results are so valuable, and if much time must be occupied in reaching the understanding of farmers, this slow process cannot begin too soon, nor can its advantages be kept too persistently before their minds.

"There is weighty and abundant evidence that the flowers of most kinds of plants are constructed so as to be occasionally or habitually cross-fertilized by pollen from another flower, produced either by the same plant, or generally, as we shall hereafter see reason to believe, by a distinct plant. Cross-fertilization is sometimes ensured by the sexes being separated, and in a large number of cases by the pollen and stigma of the same flower being matured at different times. It is also ensured, in many cases, by mechanical contrivances of wonderful beauty, preventing the impregnation of the flowers by their own pollen. Again, there is a class, in which the ovules absolutely refuse to be fertilized by pollen from the same plant, but can be fertilized by pollen from any other individual of the same species. There are also very many species which are partially sterile with their own pollen. Lastly, there is a large class in which the flowers present no apparent obstacle of any kind to self-fertilization; nevertheless these plants are frequently intercrossed, owing to the prepotency of pollen from another individual or variety over the plant's own pollen."

There are, however, some cases which seem especially contrived for self-fertilization. The number is much smaller than would be supposed by a hasty observation.

Andrew Knight, more than seventy-five years ago, said that "Nature intended that a sexual intercourse should take place between neighboring plants of the same species." Mr. Knight, and many since his time, practiced cross-breeding plants quite extensively, for the purpose of obtaining new and improved varieties. At present, there are many experts in this art in Europe and in this country.

By cross-fertilization is meant "a cross between distinct plants which were raised from seeds and not from cuttings or buds." In the proper sense, then, we could not cross a flower of one Northern Spy apple-tree with the flower of another tree of the same variety, as they have all come from the grafts or buds of one seed. In like manner, it would not be a cross to fertilize a flower of the General Grant geranium with others of the same variety, because all our plants have come from cuttings of one parent plant, or some of its descendants.

Many of Mr. Darwin's plants were raised from seeds which were sown at the same time, near each other. The best young plants from the seeds of crossed flowers, and the best which came from self-fertilized flowers were planted on opposite sides of the same pot, where the soil was well mixed. "In comparing the two sets, the eye alone was never trusted."

Fifteen plants of Indian corn from crossed seed exceeded in height fifteen others from self-fertilized seed, as 100 exceeds 84. He experimented with plants of the common Morning Glory for ten generations, using the same number of plants from crossed plants as from those self-fertilized. The average in height for the ten years is as 100 to 77 in favor of the crossing.

The flowers of this plant are freely crossed if left to themselves, exposed to insects. It is, then, altogether likely that the seeds with which Mr. Darwin began were from crossed flowers, yet, in the first generation, the seeds of crossed plants exceeded those self-fertilized as 100 exceeds 76. If we compare the number of seeds and capsules produced in the first generation, the crossed plants exceeded the others as 100 exceeds 64. The relative superiority of the crossed plants is chiefly due to their producing a much greater number of capsules, and not to each capsule containing a larger average number of seeds. When self-fertilized for nine generations, the flowers were of a uniform tint, as those of a wild species, while those in the beginning were of various colors. The crosses, so far mentioned of the flowers of Morning Glory, refer to crosses of different plants raised in the same garden, year after year. After nine generations, he introduced seeds raised at a distance, under different circumstances. Plants from these were crossed with plants which had been intercrossed in his garden. This cross (called the Cochester-crossed) exceeded in height the other intercrossed plants of the tenth generation, as 100 exceeds 78. In number of capsules, they were to each other as 100 to 57, and the capsules, in weight, as 100 to 51, in favor of those crossed with foreign stock.

Here we get a most important fact, not learned by Mr. Knight, or any one else, that a cross from a fresh stock increases the size of plant and its fruitfulness, probably owing to their differing somewhat in constitution or character. *The*

*The effects of cross and self-fertilization of plants, by Charles Darwin.

crossing of closely related plants is generally an improvement over self-fertilization; but, crossing with foreign stock of the same variety, is a far greater improvement.

The proof of the truth of the above sentence in italics is worth untold sums to the raiser of vegetables, the florist, the pomologist, to the general farmer.

In the sixth generation of the self-fertilized Morning Glory, appeared a single plant which conquered its crossed opponent by half an inch in height. Its descendants continued vigorous and fertile, even when self-fertilized. They were not profited by a cross with a distinct stock. Mr. Darwin adds that if this latter part is trustworthy, it is a unique case, as far as he has observed in all his experiments.

Agricultural College, Lansing, Mich., April 28, 1877.

Germination.

BY BYRON D. HALSTED.

A seed is a body consisting of a little plantlet called the embryo; a quantity of nourishing material, either in some portion of the embryo or around it, and the seed coats which form a protective covering for the whole. Under proper conditions this seed is capable of growing into a plant like the one from which it came, and then, in turn, produce seeds after its kind. The changes which a seed undergoes until it has become a plant, able to elaborate its own nourishment, are included under the common term *germination*, to the consideration of which further remarks will be devoted.

The general conditions of germination are familiar to all. We place the seeds in the soil, and there they soon swell, the coats are broken, and a portion which we call roots soon grows down into the soil, and a more conspicuous part pushes upward into the air and sunshine, consisting of the stem with its leaves. But let us go a little further and see more nearly the conditions which the soil affords, or in other words, what the requirements are that seeds may germinate.

One of the leading essential conditions is a certain degree of moisture, varying to a considerable extent with the species. In the absence of moisture seeds may be kept for an indefinite length of time. A limited range of temperature is also necessary. In our climate the range for the best growth of ordinary plants is between 50 and 90 degrees Fahr., while some plants, like the chickweed, will germinate when the temperature is but little above freezing; and on the other hand many tropical plants require a warmth a hundred degrees higher than this point. A free access of oxygen gas is also required for the process of germination. These three, namely: moisture, warmth and free oxygen, are the leading essentials, and when these are provided, either artificially or naturally, as by the soil, seeds may be expected to grow. The exclusion of the light, which the soil from its nature provides, is not at all essential to germination, as many experiments in growing plants in open daylight all go to show.

Having the conditions before us, let us see if we can arrive at any reasons for these conditions. There are three principal processes in the germination of a seed: First, the solution of the nourishing material; secondly, its transfer to other parts, and lastly, its transformations into cell structure or other forms of necessary material. We all know that water is the great solvent and vehicle of transfer of all substances which enter into forms of life, either animal or vegetable. Then in order to have growth there must be transfer, and in order to have transfer the substances to be moved must be in solution, and as water is the ready solvent we see the importance of it in the growth of seeds, which are bodies usually characterized by their hardness and dryness. What has been said of moisture applies equally well to temperature, as these two essentials work together to produce the necessary changes of germination. It is self-evident that the temperature must not overstep those limits at which on the one hand water becomes a solid, and on the other vapor; the point for most satisfactory results, being not far from a mean of these two extreme points. To complete the subject of the solution of the food materials, it is evident that the water and warmth of themselves could not dissolve all the substances, as for example starch, and therefore we must look for another action here. All seeds are provided with a small amount of a very powerfully acting nitrogenous substance which has received the name of *diastase*, to which is attributed in presence of water and warmth the power of engendering a kind of fermentation, by which means the starch is changed into dextrin and sugar, substances readily soluble in water. In like manner the insoluble albuminoids are rendered soluble and available for plant growth.

After having our substances dissolved we must look for a force to move it to the proper place for further use. The common source of power is in the oxidation, or combustion of vegetable substances in the form of wood or coal. In germination we have the same process of decomposition taking place, in that way bringing about a better disposition of the food material at the expense of the destruction of a portion of the same. A germinating seed, until it assimilates for itself, is continually losing in the weight of its dry substance, though it may have changed its form greatly, and even considerably increased in size. To go a step into the chemistry of this action, it is supposed that we have about the opposite changes here that take place when starch is made in the chlorophyll cells of the leaves. Starting with starch, we have as products of oxidation, carbonic acid and water, and the power of the sunshine, if we may be allowed the expression, set at liberty, as a potent and essential force.

The following table was obtained by Boussangault, after a series of experiments upon the germination of corn in darkness, and tells the same story, only in figures instead of words. The analyses figured were made before the plants had taken substance from any source outside of the seed.

	Total Weight.	Starch and Dextrin.	Glucose and Sugar.	Oil.	Cellulose.	Nitrogenous Material.	Mineral Material.	Substances not Determined.
Grains,	8.626	6.386		0.463	0.516	0.880	0.156	0.235
Plants,	4.529	0.777	0.953	0.150	1.316	0.880	0.156	0.297
Diff'ce,	—4.107	—5.609	+0.953	—0.313	+0.800	0.000	0.000	+0.062

We see a great loss of total weight, and still greater loss of starch, while the cellulose is largely increased and considerable sugar still remains. The finest illustration of germination is seen in the preparation of malt, where the process of changing the insoluble starch into the soluble sugar is carried on in a grand scale, and the oxidation becomes evident in the form of a considerable evolution of heat.

Bussey Institution, May, 1877.

Onion Smut.*

The twenty-fourth Annual Report of the Secretary of the Massachusetts State Board of Agriculture, contains among its other valuable articles one, accompanied by a plate, by Dr. W. G. Farlow on the *Onion Smut*, of which the following is a brief summary:

This peculiar disease, which has caused serious damage to the onion crop in various parts of New England, makes its appearance in May, when the onion plants are quite small. "The disease is first recognized by the appearance of a black substance in the central part of the leaves, the epidermis of which is soon ruptured, showing the center of the leaf to consist of a black powder traversed by a few stringy fibers. By a thorough examination of various New England Agricultural journals and reports, the author finds but scanty references to the smut plant, and concludes that the ravages of the disease must be confined to the last few years. 'The fungus, which is peculiar to America, has, as far as we know, never been described.' Mr. C. C. Frost gave it the name of *Urocystis Cepulæ*, which is adopted in the article.

"Microscopic examination shows the black powder consists of a vast multitude of minute spores. A short distance from these black masses the tissue of the leaves is seen to be filled with the fine threads of the fungus, which penetrate as a net-work among the cells of the leaf.

"Repeated trials upon the germination of the spores went to show that germination only takes place after a certain interval of rest of the spores."

With the use of the plate, in which are figured, the plant under consideration, rye-smut (*Urocystis occulta*), and spores of the corn-smut (*Ustilago Mayidis*), the relations which the onion smut bears to some of the other members of the order *Ustilagineæ* are pointed out. From whence did the onion-smut come? is answered in part and as well as may be, by showing that it is not of European extraction because it is not known there. "Spontaneous generation is, of course, in the present state of science quite insupposable. * * * The most probable supposition is that the onion-smut came originally from some of our wild species of onion."

How may the disease be checked? is the great practical question. The smut plant is not presumed to be a polymorphic fungus, like the rusts, having its different states on different species of plants; but confined in its growth to the onion. If the smut came from the wild onion it would be a wise precaution to destroy all such plants, especially should they be growing near the cultivated species. There is little opportunity for the smut to be propagated by the onion seed. "Very few of the plants affected by the disease ever ripen seed, and of the seed plants, the fruit does not ripen until the smut has mostly disappeared from neighboring plants. * * * It would be well to let the seed soak in water for some hours, that if by any accident any spores are adhering to them, they may be washed off."

To exterminate the spores is the most important as well as most difficult problem. Wherever they are, circumstances being favorable, the smut will appear. Nothing which can be put into the soil in the way of manure is at all likely to kill the spores. The common expression, "the disease is in the ground," is a true one, as the spores are there preserved. Grounds on which the disease makes its appearance should be burned over in June, or in Autumn, rather than not at all. "In neither case should the soil be previously dug up, for, by so doing, the spores, most of which are on or near the surface, are only the more likely to be removed beyond the reach of the fire." Agricultural implements which have been used in diseased fields should be thoroughly cleansed before using elsewhere.

The observations of Wolff on the spores of the closely allied rye-smut, coupled with the limited experience of American onion growers, go to show that the germinating power of the smut spores is retained for about four years. This being the case, should the onion fields be given over to other crops, for a short series of years, the soil would doubtless be restored to its healthy state. In just those localities where

*Onion Smut: an Essay presented to the Massachusetts Society for Promoting Agriculture, by W. G. Farlow, Assistant Professor of Botany in Harvard University.