the *soluble* compounds of lime, magnesia, iron, etc., with organic or inorganic acids—conditions which are rarely wanting in an agricultural soil."

E. H. L.

NATURAL AND ARTIFICIAL LOSSES OF FERTILITY.—The following table by Stockhardt, in view of the present agricultural practice, is of interest. It will be seen that cultivated crops make a far greater demand on the soil than those of natural growth, and thus fields which have become agriculturally unfertile, may yet contain enough fertility to satisfy the wants of a natural crop:

1000 LBS. OF DRIED PLANTS CONTAIN,

	Nitrogen.	Phosphoric Acid.	Potash.
Pine forest, 80 years old,	3 lbs.	¼ lbs.	½ lb.
Mead. grass, (hay & aftermath,)	14 "	16 "	17 "
Wheat, ripe,	10 "	4½ "	5½ "
Rye, ripe,	9 "	4½ "	6½ "
Barley, ripe,	11 "	4¾ "	7 "
Oats, ripe,	10 "	4½ "	7 "
Potatoes, (roots and foliage,)	16 "	6½ "	22 "
Tobacco, green,	20 "	5¼ "	24 "

Although these figures may not be absolutely correct for any one given case, yet they have a relative importance, which is well deserving of attention.

STREET DUST.—Signor Parnetti, has, during the last four years, analyzed the dust and *debris* of the streets of Florence and Paris. His investigation of the *debris* of the horse-paths, proves that the dust contains 35 per cent. of iron given off by the shoes of the horses. In the dust from the sidewalks, he finds from 30 to 40 per cent. of good glue. Signor Parnetti selected and treated separately, the dust from the causeways of the Boulevard des Italiens during a period of two months, which uniformly gave 30 per cent. of good transparent glue, it is said quite equal to Belfast glue. He proposes to place his discoveries at the service of a limited company, with a view of establishing blast furnaces on the banks of the Thames, to recover the iron thus lost, and a large glue works, which, it is thought, will produce more glue from the wasted material, than will supply all London for every purpose. Ex.

Botany and Horticulture.

Roots: their Structure and Functions.

BY BYRON D. HALSTED.

Modern botanists have placed all the various parts of plants under four general divisions which are called members; namely, roots, stems, leaves and plant hairs.

Let us look for a few moments at the first of these, and especially in the light which the compound microscope lends to our vision. Roots are generally subterranean, pushing their way in all directions in the soil; but this is not always the case, as many have aerial roots like those of some orchids, banyan tree, etc.; and in order that the definition may hold without exception, something more than position must be added. This is found in this generalization: roots are outgrowths, the tips of which are always provided with an outgrowth called

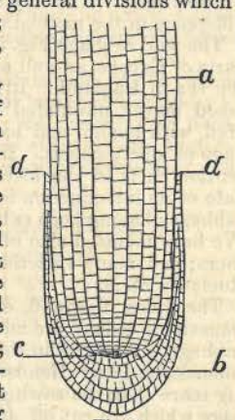

Fig. 1.

The Root Cap.

But what is this cap and why are roots thus provided?

In the above figure (1), the tip of a small root is shown much magnified and in longitudinal section through its middle. The upper portion, *a*, is the ordinary root which makes up the whole member except the portion at the extremity, which is never more than a fraction of an inch in length. In many roots the caps are not noticeable to the naked eye, while in others, as in some water plants, they make the roots appear quite club shaped. At *b* is shown the cap which covers the end of the root, as the tip of a glove does one's finger, only much more closely, and extends back on either side to *d* as seen in the cross section. This cap is made up of a simple tissue consisting of but a few layers of thick walled cells, increasing in number towards the extremity.

Fig. 2.

Roots grow in length only at small palace directly back of the central portion of the cap, (Fig. 1, *c*,) while on the other hand stems elongate throughout the whole length of the year's growth. The former are usually subterranean and push themselves along through the harsh and sharp angled particles of earth, throwing out here and there side roots, which in turn produce lateral offshoots until the earth is frequently filled with a net-work of interlacing roots. Were roots to elongate throughout their whole length, as the stem is well able to do in the atmosphere, there must necessarily result a constant dislocation of the roots, and a distangled, fractured mass, and in some cases an upheaval of the earth and the whole root system.

We see, then, the necessity of an old root and its "tributaries" remaining immovable in its position, only being allowed to increase slowly in size by successive layers near the surface, while all the extensions of the root system must be done by additions near the extremity. Where new growth is taking place there must be an accumulation of assimilated material which is passing into the structure of these walled cells, thus constituting what is called a formative tissue; from its very delicate nature this young tissue could not withstand the destructive agencies which would act upon it were it not protected. We have thus seen that the root cap acts as a protection to the tender forming tissue within. This cap is re-inforced from time to time by new layers from within as the outer and older ones are worn away.

Absorption by the Root.

Aside from the mechanical offices which the roots fill in fastening and supporting the aerial portion of the plant to the soil: and sometimes furnishing a store-house for food, the principal function of this member is that of absorption. This absorption is performed in good measure by the younger portions of the roots whose cells are thin-walled and have not become hard and woody. The old idea that this process was performed by "spongioles,"—visionary enlarged and porous tips,—since the days of the compound microscope has been discarded, and the more durable root cap has taken their place at the extremity of each root.

Figure 2, sketched from one of Sach's illustrations on the subject of roots, shows two growing plantlets of white mustard. At the extremity of each root for some distance back the surface is smooth, but beyond this in *a*, the multitude of long, slender hairs are seen thickly covering the root; while in the other the soil has been left as it naturally clings to these hairs when the plant is taken from the soil. That these hairs greatly increase the amount of absorbing surface, and also allow this surface to apply itself closely to the particles of soil is too evident to be insisted upon. Any one who will stop to take up almost any young plant and carefully wash it will, especially if he is provided with a hand lens, notice all that figure 2 is intended to illustrate.

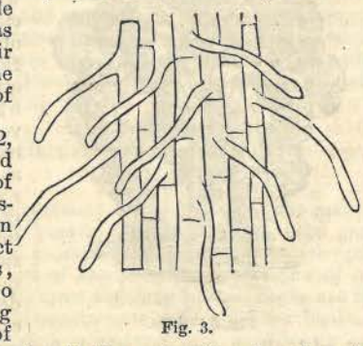
Fig. 3.

In Fig. 3 is shown a more magnified view of a small portion of the surface of a young root provided with hairs. It will be noticed that these hairs are simply the surface cells prolonged into lateral tubes; and in this way their absorbing walls are carried out into the soil for some distance around.

In Fig. 4 are shown some tips of root hairs from Sach, and magnified 800 times. It shows how closely these irregular flexible growing cells cling to the particles of soil amongst which they pass. The symmetry and beauty of these extremities is lost in their close intimacy with the earth. From this figure it is seen how it might be easier for the hairs to break from the root than loosen from the soil. This thought suggests the great care which should be observed in transplanting or otherwise changing plants, that these little root hairs be as little disturbed as possible. Though they are not permanent structures of the plant like the root itself, they are extremely essential to its proper development. Individually they may not endure for a month; but their place is filled by new ones which have successively formed nearer the growing point in new regions of nourishment.


Fig. 4.

Darwin's Cross and Self-Fertilization of Plants. II.

BY PROF. W. J. BEAL.

Early Maturity Gained.

I have said that plants crossed with a foreign stock were in a great majority of cases taller, larger, heavier, more vigorous, or better able to endure crowding by other plants. They also endured inclement weather better. In another respect Mr. Darwin has shown their superiority. In 58 cases "the period of flowering of the crossed and self-fertilized plants was recorded. In forty-four of them a crossed plant flowered first either in a majority of the pots or in all; in nine instances a self-fertilized plant flowered first, and in five the two lots flowered simultaneously. One of the most striking cases is that of Cyclamen, in which the crossed plants flowered some weeks before the self-fertilized in all four pots during two seasons." In some cases, as with *Lupinus luteus* and *Clarkia elegans*, the crossed to the self-fertilized plants in height were to each other as 100 to 82, yet *Clarkia* flowered first.

Numerous experiments showed that the crossing of one flower with that of another on the same plant seldom if ever does any good. All the flowers are subjected to the same conditions. In tables given, "in thirty-five out of fifty, flowers fertilized by pollen from a distinct plant yield more, sometimes many more seeds than flowers fertilized with their own pollen; and they commonly set a larger proportion of capsules."

Considering all the facts brought forward "it is difficult to avoid the suspicion that self-fertilization is in some respects advantageous," though he says if this be really the case the advantage is quite insignificant compared with that from a cross with a distinct plant, and especially with one of a fresh stock. In ten out of sixteen cases the self-fertilized seeds were either superior or equal to the crossed in weight. This the author partially accounts for "by the self-fertilized cap-

sules containing fewer seeds," which on this account had a better chance to receive an abundant supply of nutriment.

Effect on Germination.

In twenty-one cases a record was kept of the relative period of germination of crossed and self-fertilized seeds. In one case the seeds germinated simultaneously; in ten cases the self-fertilized seeds germinated before the crossed, and in the other ten the crossed seeds germinated first. After knowing the great advantage to be derived from cross-fertilization, we are prepared to understand that honey is placed in flowers as wages to pay insects for serving the plants. The gay colors and odors are advertisements to call the attention of insects to the rich supplies of food in store for them. Saunders, of Canada, cut off the petals of raspberries, and by so doing made it difficult or impossible for the bees to find honey. "Almost every fruit which is devoured by birds presents a strong contrast in color with the green foliage, in order that it may be seen and its seeds freely disseminated."

Fig. 5.—Wild Cabbage.

Natural Provision for Crossing.

Among many other topics of interest Mr. Darwin gives part of a chapter on the means which favor or ensure flowers being fertilized with pollen from a distinct plant. We have seen that a cross of different flowers on the same plant does but little good. One insect will often visit an astonishingly large number of flowers in a small space of time. They cannot tell whether a flower contains honey or not till they try it. In this way any flower is frequently visited by many insects in turn, some of which will very likely bring pollen from other plants. A single plant of a species rarely grows alone. There are others near by. Dicœcious plants* must be crossed. When monœcious† there is a good chance for a cross, especially where the anthers ripen before the pistils are ready for the pollen or the reverse. The expansion of only one or a few flowers at a time on a plant favors a cross of two distinct plants. Dimorphous is a term applied to plants which have stamens and pistils of two different lengths. For example, the flowers of *Primula* on one plant will have all the pistils running to the top of the tube of the corolla, while the stamens will be below; yet on another plant the stamens may be near the top of the tube while the pistil is below. This is the case with *Bouvardia*, *Houstonia* and many others. They are dimorphous. The long styles on one plant are more certain to be fertilized by the tall stamens, and when so crossed produce seeds best; while the short stamens or those low down are fitted to cross the short styles.

He planted a white kohl-rabi, a purple kohl-rabi, a Portsmouth brocoli, a Brussels sprout, and a sugar-loaf cabbage (varieties of one species) near together and left them uncovered. A majority of seedlings from these seeds in all five beds were mongrelized in the most complicated manner. Some other experiments were made with other plants giving similar results, as onions and mimulus.

*Having male and female flowers on different plants.
†Having male and female flowers on same plant, but the sexual organs not in the same flower, as in Indian corn.

Difference in Pollen.

In numerous cases he placed pollen on the stigma from anthers of the same plant, and in twenty-four hours added pollen of another variety. In every instance some or all the pistils bore seeds which showed they were crossed by the last application of pollen. If one flower is fertilized with pollen which is more efficient than that applied to the other flowers on the same peduncle, the latter often drop off. This was shown by experiments of Herbert and others. The amount of pollen produced by plants which are dependent upon the wind to fertilize them is very large. Pollen in some cases drifts for hundreds of miles and rises to the height of 500 to 1,000 feet. This gives a great opportunity for many of our evergreens and other trees and plants to be crossed by distant plants.

Bees as Specialists.

Chapter eleven is devoted to the habits of insects in relation to the fertilization of flowers. From a previous paper read at the Michigan Bee-keeper's Convention the writer of this review remarked, that "Individual bees have been observed to behave differently about flowers, in some respects, from a majority of bees. Some are eccentric. They have their peculiarities. Nageli put artificial flowers to branches, and used essential oil on some, and on others he used no oil. The odor attracted them to the flowers containing it. Aristotle, 2,000 years ago saw that hive bees worked continuously on flowers of the same species. They even do so when the flowers are not all colored alike, as in some plants in our flower gardens. By this means they economize time. They get the hang of it. They learn how better to make more rapid motions, and to make every motion count. The same as is true of people who become expert in certain parts of any trade after much practice in often repeating the same operation."

A Practical Suggestion.

The twelfth and last chapter of this fertile book is devoted to general results. Like most of the other chapters, to do it justice would require long quotations. The seeds from a plant are benefited by the flowers having been fertilized by pollen of another plant which had been subjected to quite different conditions. This is brought about in many instances in the same spot where seeds have lain covered or dormant for some years, and then are turned up or placed in favorable condition to grow and mix with plants from seed produced in later years. Seeds are no doubt influenced by being kept for a long time. "Those which were matured during different seasons, will have been subjected during the whole course of their development to different degrees of heat and moisture." "It is a common practice with horticulturists to obtain seeds from another place having a very different soil, so as to avoid raising plants for a long succession of generations under the same conditions; but with all the species which freely intercross by the aid of insects or the wind, it would be an incomparably better plan to obtain seeds of the required variety, which had been raised for some generations under as different conditions as possible, and sow them in alternate rows with seeds matured in the old garden. The two stocks would then intercross, with a thorough blending of their whole organizations, and with no less of purity to the variety; and this would yield far more favorable results than a mere exchange of seeds."


Fig. 6.—Kale.

Agricultural College, Lansing, Mich., Aug., 1877.

[Those interested in this very interesting review, may be interested to learn that the book is for sale at this office. See advertisement.—Eds.]

The Cabbage Tribe. 1.

In the cabbage tribe we have a beautiful illustration of the changes which have been brought about in vegetables through the art of man, and it is interesting and valuable for us occasionally to retrace the path that man has been over, and seek what he has accomplished in order that we may be able to form an idea of his powers, and the possibilities which stand ready to be developed.

We find that naturalists classify under the same group or genus: the cabbages, cauliflowers, Brussels sprouts, borecoles, kales and kohl-rabi; and as well the Swedish turnips and colzas, the common turnips and rape. The name of this group is *Brassica*, and the wild cabbage is called *Brassica oleracia*. How widely different at first sight the cabbage and the kohl-rabi, the Brussels sprouts and the cauliflower! Yet they have all descended from the same parent, the *B. oleracia*, and are not considered botanically distinct.


Fig. 7.—Brussels Sprouts.

Darwin compared the flowers and the seeds of all the principal kinds, and noted no characteristic difference. Yet any child even can see the difference in the method of growth of the plants.

The wild cabbage Fig. 5., is a native of various parts of Europe, as well as of several places near the sea in England. It is a biennial, with fleshy lobed leaves, undulated at the margin and covered with bloom, and looks very unlike the cabbage of our gardens. It must have received attention early in the history of mankind, for the date of its introduction is concealed in the past, cabbages having been cultivated by the old Celts. We have mention also of coles in the Greek authors; and many varieties are spoken of by the Roman writers.

The kales, figure 6, or coleworts as they are sometimes called, are an open-leaved variety of cabbage. As used in this country, coleworts or collards, as Peter Henderson remarks, are nothing more than the sowings of any variety of cabbage which are cut off and used when about six inches high. There are various other names for this plant, such as borecole, Germangreens and curlies. The kales make excellent greens for use in fall and early winter, being nearly as desirable as the spinach. This plant was very carefully cultivated by the ancient Romans, and is now extensively used in Scotland, its name frequently appearing in the national songs and proverbs of that country.

Brussels sprouts, figure 7, is a form of the cabbage whereon the stalk is elongated, with the lateral leaf-buds mostly forming heads, as will be seen in the illustration.

The parts used are the small heads from the stalks, which are very sweet and tender. Curi-