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N. A. Waterman

# POPULAR ERRORS

## ABOUT PLANTS

BY

A. A. CROZIER.

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# Publications by A. A. GROZIER.

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# CONTENTS.





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# PREFACE.

IT would be a thankless service indeed if this contribution to the history of errors were nothing more than a mere exhibition of certain mistakes and delusions. However prone any of us may be to observe and criticise the errors of others no right minded person can seriously contemplate imperfection of any kind with any degree of pleasure; the search for errors has in it none of the satisfaction which rewards the seeker after truth; except, therefore, as a basis for juster views of plant life, and as a lesson of caution against accepting beliefs not founded in reason, this little work has no excuse for its existence. But if it shall, to some extent, enable those for whom it was prepared to see more clearly some of the principles which underlie the operations of the farm and garden, and lead them to rely with greater confidence on their own ability to understand these natural laws it will have fulfilled the leading purposes for which it was written.

Next to acquiring knowledge, one should desire to know where reliable information may be obtained. Ignorance is chiefly disastrous when united to self-confidence. Although the following pages record many mistakes made by men of science, they nevertheless show that the true interpreters of nature's laws have nearly always been those who have given some branch of science long and earnest study. It is easy to understand almost any principle of science, but it often requires years of patient effort to discover and demonstrate a simple natural law. We need to know who the original workers are, and who are best informed on all scientific subjects. It is because we do not always know whose opinions are most to be relied upon that erroneous beliefs remain so long among us. Nor can it be said that the educated always fulfil their whole duty in rendering information accessible to others. It is to be feared that they sometimes have too little sympathy with those who are unfamiliar with subjects to which they themselves have devoted their attention; and they possibly fail at times to appreciate the capacity of every-day people to understand what is called scientific truth. If there should be such an impression in the mind of any teacher who may have occassion to consult this book he will doubtless become convinced by its contents that erroneous theories are often quite as complicated and difficult of comprehension as the average propositions of science. Nothing is more true than that every healthy mind seeks for an explanation of all phenomena which come to its notice. So strong and universal is this desire that most of us will accept any explanation, however absurd, rather than remain in doubt. This being the case, it certainly rests with those who can give true explanations to do so. Too often the leading facts of science are taught only to regular learners in schools and colleges, and fail to reach the outside world, where, after all, most of the lessons of life are learned. I can think of no better way of impressing a truth upon one who has no time for systematic study than to offer it in exchange for an error already held. In recording the following popular errors, therefore, I have frequently given in connection with each topic a brief account of the best existing information upon the subject.

It is needless to say that this is not a text-book or a systematic work on popular science; but if the suggestions it contains, and the fragmentary insight into a knowledge of plants which it affords, shall lead any to seek further information upon the subjects treated the wish of its author will be gratified.

# I.

## SPONTANEOUS GENERATION.

ALL antiquity, down to the end of the Middle Ages, believed in the spontaneous generation of both plants and animals, that is to say, their origin directly from the earth or other dead material without a previous germ or egg. Three centuries before the Christian era Aristotle taught the spontaneous origin of eels and other fish out of the slimy mud of rivers and marshes; also that certain insects originated from the dew deposited upon plants, that lice were spontaneously engendered in the flesh of animals, and that caterpillars were actually the product of the plants upon which they feed. Von Helmont, who died in 1644, described in detail the conditions necessary for the spontaneous generation of mice! Dr. William Harvey, the discoverer of the circulation of the blood, has the credit of first propounding the principle that no life could exist without pre-existing life. He maintained that all living things proceeded from eggs, but just what he meant by eggs seems to be uncertain, though he probably included in the term seeds and germs of all kinds.

Francesco Redi, an Italian physician, seems to have been the first to discover (in 1668), what it now seems difficult to believe that anybody could have ever failed to observe, that the maggots found in putrefying meat were not a direct product of putrefaction, but came from eggs deposited by flies. He proved this to the doubting people of his time by placing some meat in jars having gauze over the top, when the meat within the jars decayed as usual, but contained no maggots.

During the revival of learning, at the close of the Middle Ages, the belief in spontaneous generation gradually died out. Upon the invention of the microscope, however, and the discovery of low forms of life, the existence of which were before unknown, it came to be believed by scientific men that these organisms were exceptions to the general rule, for it was seen that wherever suitable conditions for their growth existed they made their appearance.

Pasteur of France, who is still living, undertook, almost unaided, to refute this opinion, and succeeded so well that his results have been accepted throughout the scientific world. Students of fungi, bacteria, and other microscopic plants and animals, now take it for granted that wherever any of these organisms appear it is conclusive evidence that there were previously present germs of the same kind.

Intelligent people have now become so accustomed to the thought that every living thing comes from a pre-existing germ that it is difficult for us to understand that any other belief was ever held. When Pasteur, however, first began his demonstrations that were to banish the last remnant of the belief in spontaneous generation from the educated world he was vehemently opposed by the leading scientific men of the time. His chief immediate opponents were Pouchet of France, who devoted a volume to the advocacy of the spontaneous generation of microscopic organisms, and Liebig of Germany, the eminent chemist. Liebig held that fermentation is a change undergone by nitrogenous substances under the influence of the oxygen of the air. Pasteur proved that the alcoholic yeast plant, which had long been known, but which had not been regarded as of particular importance, was the real cause of alcoholic fermentation. He discovered also the germ which causes the fermentation which takes place in the souring of milk, and made many other discoveries of a similar nature. He proved that when these germs were excluded no fermentation took place.

One of his experiments was to take a tube containing a liquid liable to fermentation, destroy by heat all the living germs it might contain, then admit air which had passed through a red-hot tube to kill the germs which the air contained. Under these conditions the liquid was found to keep for any length of time without fermentation. The presence of living germs in the air was proved by actually collecting them by drawing air through plugs of gun cotton; the numerous minute bodies which are usually floating in the air were rendered visible to those who doubted their existence by admitting a beam of light into an ordinary darkened room. The fact that the visibility of the beam depended wholly on the reflection of the light from the suspended particles in the air was proved by keeping the room closed until all the particles had subsided, when the beam was no longer visible, though admitted by a small opening as before. By these and many other ingenious experiments Pasteur proved the almost universal presence of living germs, and their ability to originate all known cases of fermentation and putrefaction. A debate with Pouchet and others on this subject before the French Acadamy was carried on for months during the years 1861–62, and resulted in a triumphant vindication of the principle for which Pasteur contended. It was not until after the Franco-Prussian war, however, that Liebig, declining to discuss the question longer, virtually admitted that the fermentation of liquids was due to the presence of living ferments derived from the air as claimed by

Pasteur, and that others who held that these and other similar organisms were capable of originating directly from non-living matter ceased to advocate their belief.

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# II.

## VITALITY OF SEEDS.

NOTHING in connection with forests has attracted more attention than the springing up of a different kind of timber when one forest growth is removed by the ax or fire. This has been attributed to the exhaustion of certain elements in the soil, rendering necessary a natural rotation of species, in order to maintain the continued growth of vegetation, thus furnishing a grand lesson from nature on the importance of a rotation of crops. Without discussing at present the truth of this explanation, or the frequency with which such a natural rotation of forests actually occurs, the case is presented as a familiar illustration of the appearance of plants where none of the same kind were known to exist before. The apparently spontaneous growth of immense quantities of Fireweed, and other species rarely found in either cultivated land or natural forests, on ground which has been newly cleared, is a similar instance of the growth of vegetation where there is no visible supply of seed. Such cases were formerly regarded as conclusive evidence of spontaneous generation, a belief held by the ancients, not only with regard to plants, but concerning many forms of animal life also. The advance of science, especially by means of the microscope, has overthrown the argument for spontaneous generation, and there is hardly an intelligent person in any civilized community to-day who does not know that every plant, whether large or small, originates from a seed, or germ. But this conclusion renders it impossible to account for the appearance of new forms of vegetation in such cases as have been referred to unless we can show the origin of the seed. The difficulty of accounting for the origin of the seed from any plants living in the vicinity made it seem probable that the seeds from which they sprang were transported to the locality many years before and have retained their vitality by being protected by the soil and a covering of leaves, until the removal of the forest, or perhaps the burning of the protecting leaves, admitted the sun and air and furnished the conditions for germination. Other causes besides the removal of forests have furnished new conditions which have brought into being new forms of vegetation. I have in mind the case of an old farmhouse which had stood for at least 200 years and which was pulled down, when there appeared on the site a thick growth of Charlock or Wild Rape, a plant wholly new to the neighborhood.

In an editorial in the *Gardeners' Chronicle* for 1863, page 1, 228, an account is given of the following observations by Mr. G B. Wollaston of Chislehurst, on the Mid-Kent Railway:

"Certain excavations were necessary, and these had to be made to a depth varying from five to ten feet in the virgin sand and gravel of the district. Thereupon *Erigeron Canadense* sprang up everywhere, so as to completely cover the earth to the almost total exclusion of other vegetation. The Erigeron was not previously known to grow in the neighborhood. Indeed it is one of the so-called rare species, of which comparatively few habitats are known in England, and even its claim to rank as a native plant is generally questioned. Yet, the interesting fact Mr. Wollaston records, though not to be taken as exact evidencé, seems to afford strong presumptive proof that the plant is a true native, and that its seeds must have been buried for an indefinite period in the soil."

In "Schoolcraft's Missouri" (1819), page 29, Henry R. Schoolcraft says: "The soil thrown out of the pits sunk in search of ore also produces several plants and trees which are not peculiar to the surface. Such are the Poplar or Cottonwood, and Beach Grape, which are found to flourish only on the rich alluvial lands composing the banks of rivers. Nevertheless, I have seen these growing about the mouths of long neglected pits, the soil of which had been raised thirty or forty feet, or where previous to digging no such trees or vines existed. This fact is to be referred only to a difference in the quality of the soil at the depth alluded to, and warrants us further in the conclusion that all soils are impregnated with the seeds of the trees and plants peculiar to them, as well at great depths as on their surfaces."

A similar case is quoted by Geo. P. Marsh, in his work on "Earth and Man." On the Penobscot River in Maine, forty miles from the sea, a well was dug, in the bottom of which sand similar to that of the seashore was found. Some of this was placed in a pile by itself and afterwards spread about the place. The next season there sprang up in this sand a number of trees, which when they came to maturity were found to be the Beach Plum, which never was known so far from the shore. The presence of these seeds, and the peculiar character of the sand from the well, was accepted by some geologists as evidence that the sea-coast had formerly occupied that spot. This and similar instances led Professor Marsh to say that the vitality of seeds "seems almost imperishable while they remain in the situation in which nature deposits them."

Another case, which I have never seen doubted, is that of three Raspberry plants growing in the gardens of the London Horticultural Society, raised by Professor Lindley from seed discovered in the stomach of a man whose skeleton was found thirty feet below the surface of the earth at the bottom of a barron or burial mound near Dorchester, England. With the body had been buried some coins of the Emperor Hadrian; from which it is assumed that these seeds had retained their vitality for the space of sixteen or seventeen hundred years.

In the *Gardeners' Chronicle* for 1848, page 700, is an account of some seeds of Roman origin taken from a tomb in France, and referred to the third or fourth century, and therefore 1,500 or 1,600 years old.

The seeds were carefully removed and were sown by two different persons, whose names are given, together with the manner in which they were sown. From both lots there were obtained plants of *Medicago lupulina* and *Heliotropium Europæum*, and from one of the lots *Centaurea cyanus* in addition. Another case is given in the same connection of seeds found in an earthen vessel eight feet below the surface, and supposed to belong to an age anterior to the Roman conquest of Gaul. From these seeds about 20 plants of *Mercurialis annua* were grown.

But the cases which have attracted more attention than any others are those of the germination of wheat and other seeds taken from the wrappings of Egyptian mummies, or from the tombs in which mummies were found.

In a recent number of the *Christian Union* I find this statement by Canon Wilberforce, the great English preacher: "I have seen beneath the microscope a seed 3,000 years old start into instant germination when touched with a drop of warm water; so a human soul, long apparently lifeless, begins to grow when touched with the water of life." In the *New York Voice*, for March 27, 1890, is the following, entitled "Seed Corn 4,000 years Old." "During the season of 1889 a most remarkable crop of corn was raised by David Drew, at Plymouth, New Hampshire. In 1888, Mr. Drew came into possession of some corn grains found wrapped with a mummy in Egypt, supposed to be 4,000 years old. These were planted and grew. It had many of the characteristics of real corn; the leaves were alternate; it grew to be over six feet high; the midribs were white; but the product of the stock—there is where the curious part came in. Instead of growing in an ear like modern maize, it hung in heavy clusters at the top, on spikelets; there was no tassel, no silk, each sprig was thickly studded with grain, each provided with a separate husk, like wheat grains." [Evidently sorghum.]

In the *London Times* for September, 1840, Martin Farquhar Tupper gives an account of experiments on the germination of mummy wheat, concerning which the editor of the *Gardeners' Chronicle* states that he finds no flaw whatever. Following is an abstract taken from the latter journal:

"Sir Gardener Wilkinson, when in the Thebiad, opened an ancient tomb (which had probably remained unvisited by man during the greater part of 3,000 years), and, from some alabaster sepulcral vases therein, took with his own hands a quantity of wheat and barley that had been there preserved. Portions of this grain Sir G. Wilkinson had given to Mr. Pettigrew, who presented Mr. Tupper with twelve grains of the venerable harvest. In 1840 Mr. Tupper sowed these twelve grains." Of these only one grew, producing two small ears. Details are given of the pains taken to insure that the plants which might grow should come from the seed planted. The soil was carefully sifted and three seeds were planted in each of four garden pots at the angles of a triangle. The grains sown were brown and shrunken, unlike any modern wheat.

Another case, described by George Wilkes in the same journal for 1856, relates to the finding of some wheat in the wrappings of a mummy opened at Cambridge. He states that a nobleman who was present gave some of the seed to his gardener who planted it and grew therefrom three kinds of wheat different from any that Mr. Wilkes had ever seen.

A writer in the *Country Gentleman* for 1888, quotes from a recent paper read before an English society on the vitality of mummy wheat, in which it was stated that no fewer than fifty-nine species of flowering plants, raised from mummy wrappings in Egypt, had been identified.

In one instance "a sarcophagus was brought from Egypt by the Duke of Sutherland; and seeds which were taken from it, being planted, germinated."

The late Professor Alexander Winchell quotes Lord Lindsay as saying that he found a bulb in the hands of a mummy at least 2000 years old, and that it grew and produced a Dahlia. But the Dahlia does not grow from a bulb, is a Mexican plant, and was not known to botanists until 1789. Another account of this case by Rogers in his "Scientific Agriculture" speaks of it as a "root" being so found. This might do, if the Dahlia had been known in Egypt at the time indicated.

These and other instances of the supposed growth of seeds taken from the Egyptian catacombs have been published in nearly every agricultural journal and work on agriculture for the past fifty years, and have been accepted even by good authorities in science, including Doctor Carpenter of England and Professor Agassiz of our own country. The dry air and uniform temperature of the tombs of Egypt, and the protection afforded by the embalming process, which has so wonderfully preserved the ancient bodies, has been regarded as sufficient to preserve vitality in the grains which it was the custom of the ancient Egyptians to bury with their dead, either upon the body itself or in receptacles placed near them.

The subject of the vitality of seeds buried by natural agencies in the soil has been fully treated by Professor Alexander Winchell in his admirable work, the "Sketches of Creation." It is known to geologists that at the close of the Tertiary period, just preceding the glacial epoch, the climate of the United States was very similar to what it now is, though somewhat warmer. In rocks of that period, found in Kentucky, have been discovered remains of the Beech, Live Oak, Chincapin, Pecan, Honey Locust, and other trees found in the same region to-day. In the rocks of this age on the upper Missouri River have been found the Walnut, Persimmon, Tulip tree and other species, in localities which have since become too cold and dry for them. There is abundant reason to believe that in the Tertiary period the vegetation of North America was more vigorous than now, but composed of nearly the same species. During the glacial period this vegetation is supposed to have been nearly all destroyed, as far south, at least, as Alabama and Texas. How then came the continent to be re-clothed when the glaciers receded to the northward, leaving immense deposits of sand and gravel and barren rock in place of the original prairies and forests? This is the question Professor Winchell endeavors to answer. In the work referred to, in a chapter on the "Vitality of Buried Vegetable Germs," he says:

"For some years past I have been inclined to believe that the germs of vegetation which flourished upon our continent previous to the reign of ice, and many of which must have been buried from twenty to one hundred feet beneath the surface of the glacial rubbish, may have retained their vitality for thousands of years, or even to the present time." Facts, he says, show the presence of grains "where they could not probably have been introduced during the human epoch."

The remains of ancient vegetation are abundantly sufficient in all the glacial region of the northern hemisphere to have supplied these germs had they retained their vitality, and the gradual washing away of the surface by streams has been a sufficient means of bringing them to the surface. In his remarks upon ancient forests, Professor Winchell says:

"The existence of a succession of forests of different prevailing species has been satisfactorily established in Denmark by the researches of Steenstrop on the *Skovmose*, or forest bogs of that country. These bogs are from twenty to thirty feet in depth, and the remains of forest trees in successive layers prove that there have been three distinct periods of vegetation in Denmark—first a period of the pine; secondly a period of the oak; lastly a period of the beech, not yet arrived at its culmination."

Similar buried forests are found in our own country, in New Jersey, Wyoming and elsewhere. These extinct forests, he says, have no doubt "stocked the accumulating soils with their stores of vitalized fruitage." "The drift deposits became the vast granary in which nature preserved her store of seeds through the long rigors of a geological winter."

Such is the theory presented by an astute geologist, to account for the reappearance of vegetation after the glacial epoch,—as at least more probable than spontaneous generation, or the "fortuitous distribution by any modern agency." He directly adds, however: "it must be confessed that crucial observation is yet to be made. If vegetable germs exist in the drift they can be discovered before-hand. I am not aware that any thorough search has ever been made for them."*

Let us now turn to the second part of our subject and re-examine some of the cases which have been presented, and see to what extent they appear well founded, and how far they are supported by other and more direct evidence. Let us see what has been done in the way of direct observation and experiment to determine the limit of vitality in seeds, and notice whether any explanations can be afforded to account for what, if true, are certainly remarkable instances of duration of life. For seeds are living objects, and require, like all other living things, a constant supply of food to support life; and as they have no means of supplying this outside of themselves, we come, by this course of reasoning, to the idea that there must necessarily be some limit to the duration of their vitality, however abundant their supply of stored up food may be. We know that under ordinary conditions seeds vary in their limit of vitality; hence we may suppose that under even the most favorable conditions they will also vary. The seeds which in ordinary experience keep the longest are seldom those which are of the largest size, hence we infer that amount of available food is not the most important feature in

* In a recent article published in the *Forum*, Prof. Winchell shows that there is reason to doubt the belief in a continuous continental glacier.

prolonging the life of a seed. Probably seeds never lose their vitality from having entirely exhausted their supply of stored up food. The fact that seeds may germinate again and again, after having their store diminished by previous attempts at vegetation, shows that for at least the first stages of germination most seeds contain more nutriment than they need. There are two agents nearly everywhere present reducing all organized matter to the inorganic state; that is to say, two causes at work producing decay in everything of an animal or vegetable nature. These causes are, first, the oxygen of the air; second, numerous low forms of vegetable life which feed upon decaying organic matter and assist in producing decay. These outside sources of destruction are far more active in their demands upon the seed than is the living plant which it contains. To protect themselves against these destructive influences seeds are enclosed in a more or less impervious covering; and the length of time during which seeds will live depends very much upon the nature of this covering. The differences in duration of vitality among seeds however depend probably even more on the composition of the seed itself than on the character of its covering. Why it is that the thick-shelled Chestnut, Walnut and Hickory will retain their vitality only a few months, while the thin-skinned grains of corn and wheat ordinarily live as many years, we do not fully know. If we say that the oiliness of the nuts is the cause of their quickly becoming rancid, what shall we say of the oily seeds of the cabbage tribe, some of which are noted for their long vitality? It is enough for our present purpose to know that there exist recognized differences depending on the nature of the seed. That the coating of seeds is an important factor in resisting decay is seen by the quickness with which corn meal or wheat flour deteriorates, as compared with the whole grains from which they are made. Everyone knows too that the conditions under which seeds are kept have much to do with the duration of their vitality. The most favorable conditions for prolonging life in the seed are the opposite of those which favor germination. Thus, to keep seeds we put them in a dry place. Dampness, even if it does not induce the germination of the seed itself, favors the growth of fungi which destroy its vitality. Thus it is that in the damp climate of England it is more difficult to keep seeds than in this country. But moisture, if sufficient to exclude the air, or accompanied by too low a temperature for the germination of the species, may favor prolonged vitality in seeds. Under whatever conditions seeds are kept, however, there is a continual loss of vitality from the time that they ripen. It is true that some seeds ordinarily require to be of a certain age before they will germinate readily, but this time is needed for the softening and partial decay of their shells, and the incipient stages of germination; there is no recorded case of old seeds germinating with greater vigor than fresh ones.

The rapid deterioration of nearly all seeds, and the perfectly well known fact that very few kinds are reliable for planting after more than four or five years, is sufficient in itself to cast serious doubt over the statements of seeds having grown which were taken from the ancient tombs of Egypt or from great depths in the earth. Nevertheless, as one positive example is sufficient to refute any amount of presumptive evidence to the contrary, it is necessary to inquire into the accuracy of the reported cases of the germination of such ancient seeds, and to learn whether similar results have been obtained in other cases.

In 1840, the British Association for the Advancement of Science appointed a committee to conduct a series of experiments for the purpose of determining how long seeds of different kinds could retain their vitality. These experiments were carried on for ten years, and included the testing of a great number of samples of many species. Among them were samples of wheat and other grains from Egyptian and other tombs, none of which germinated. The oldest seeds which germinated were those of the Choronilla, at 42 years, and Colutea at 43 years of age; of the latter only one seed germinated out of seventy-five which were planted.

In 1843 the *Gardeners' Chronicle* published an editorial on mummy wheat, of which the following is an abstract: "Every year produces cases of this sort about the harvest season, and even this season at least twenty specimens have been sent us of wheat ears purporting to have a 'mummial' origin; and strange to say they have all proved to belong to the Egyptian wheat, or *Ble de Miracle*, called by botanists *Triticum compositum*. We have never however succeeded in satisfying ourselves that the corn from which such wheat is said to have been produced was really taken from mummy-cases. There is always some defect in the evidence."

In 1856 George Wilkes of England said: "I had three small parcels of wheat, two of them directly from Egypt, and I was assured they were taken out of mummies; the other was very old, but from whence I know not. I planted the whole very carefully, but not a grain grew."

In 1863 the *Press Scientifique des Deux Mondes* contained the following description of a series of experiments made in Egypt by Figari-Bey on the wheat found in the ancient sepulchres of that country. "A long dispute occurred a few years ago as to what truth there might be in the popular belief, according to which this ancient wheat will not only germinate after the lapse of three thousand years, but produce ears of extraordinary size and beauty. The question was left undecided; but Figari-Bey's paper, addressed to the Egyptian Institute of Alexandria, contains some facts which appear much in favor of a negative solution. One kind of wheat which Figari Bey employed for his experiments had been found in upper Egypt at the bottom of a tomb at Medinet Aboo, by Mr Schnepp, Secretary in the Egyptian Institute. There were two varieties of it, both pertaining to those still cultivated in Egypt. The form of the grains had not changed; but their color, both within and without, had become reddish, as if they had been exposed to smoke. The specific weight was also the same, viz., twenty-five grains to a gramme. On being ground they yield a good deal of flour; but are harder than common wheat, and not very friable; the colour of the flour is somewhat lighter than that of the outer envelope. Its taste is bitter and bituminous; and when thrown into the fire it emits a slight but pungent smell. On being sown in moist ground, under the usual pressure of the atmosphere, and at a temperature of 25° (Reaumer), the grains became soft, and swelled a little during the first four days; on the seventh day their tumefaction became more apparent, with an appearance of maceration and decomposition; and on the ninth day this decomposition was complete. No trace of germination could be discovered during all this time. Figari-Bey obtained similar negative results from grains of wheat found in other sepulchres, and also on barley proceeding from the same source; so that there is every reason to believe that the ears hitherto ostensibly obtained from mummy wheat proceeded from grain accidentally contained in the mould into which the former were sown."

In 1860, twenty years after the publication relative to the germination of mummy wheat by Mr. Tupper already referred to, Professor Henslow published in the Transactions of the British Association for the Advancement of Science an account of his investigation of the circumstances under which this former experiment was made. A quantity of the original lot of mummy wheat was found still in the possession of Sir Gardener Wilkinson. This was carefully examined and found to contain a few grains of unmistakably *fresh wheat*; and besides this it contained grains of *Indian corn*, a grain not known in Egypt until after the discovery of America. Further inquiry revealed the fact that the ancient wheat had been for a time in the keeping of a grain merchant of Cairo, who supplied the jars into which it was put after being taken from the catacombs. Under this new light the fact that one grain grew out of the twelve which were planted will hardly be considered as evidence that the seeds which grew actually came from the tombs. Such errors as these, together with the uniform failure of more recent attempts to germinate this ancient wheat, have convinced the scientific world that no actual germination of such wheat ever took place.

In regard to the supposed cases of the germination of seeds in earth thrown from the bottoms of wells or other deep excavations, it is very difficult to prove directly that seeds have not grown as supposed from such soils, and few actual experiments have been made upon the subject. In 1875, Doctor Hoffman reported some experiments of this kind in the *Botanische Zeitung*, in which he says: "For the purposes of the experiments about three-quarters of a hundred weight of the Loess soil was taken out at a depth of twelve feet below the surface when the earth was being leveled for the railway station at Mousheim, near Worms. A newly broken spot was selected and the tools previously cleaned with well-water. In fact every conceivable precaution was taken throughout the experiment to prevent the introduction of foreign seeds or spores. Notwithstanding all this care, various common mosses, ferns and flowering plants sprang up in the pots which were closely covered with bell-glasses.

It is noteworthy, too, that all the species that sprang up in this way were common either in the green house or its immediate vicinity, and not in the locality whence the soil was procured. A similar set of experiments was instituted with white Tertiary sand, and the result was the same; then the experiment with Loess soil was repeated again. In this instance the only plant that could possibly spring from a seed in the long buried soil was *Festuca pratensis*, but this was a delicate plant, probably from a very small light seed that might have been conveyed by the air." In 1885, I made at Grand Rapids, Michigan, two small experiments of the same nature. Three flower pots were filled with sand taken from twelve feet below the surface, and three more with surface soil. Each pot was kept covered with a pane of glass except at the time water was applied. In the three pots from the subsoil no seeds germinated, while each of the other pots produced numerous grasses and other weeds. I also took about 100 pounds of muck from two feet below the surface of a marsh and exposed it in a Wardian case kept continually closed. In this soil one plant, of a kind common on the marsh, germinated.

A few experiments have been tried on burying seeds in the soil to determine the duration of their vitality under such conditions. Professor Beal, of

Michigan, buried weed seeds of different kinds for several years and many of them when again brought to light germinated. I buried seeds of corn, beans and buckwheat five feet deep in sandy soil. All were dead at the end of a year, though some had first germinated. Nevertheless, cases are known where seeds have retained their vitality in the soil longer than they ordinarily do in the open air.

Henry Doubleday states in the *Gardeners' Chronicle* for 1885, page 854, that seeds of *Lavatera arborea* continued to come up in his garden for twenty years, though none were allowed to seed there during that time.

M. J. Berkley, in the same journal for 1863, page 1011, describes an abundant growth of "water-cress, with a slight admixture of *Ranunculus aquaticus*, and some grass" in the muck of a pond which had been filled for 33 years. "The seedlings burst out from the edge of the soil where it had been cut through with the spade, taking their origin beneath the superincumbent rubbish." The seedlings were growing three feet below the general surface at the time of observation.

C. M. Hovey, of Boston, said in the *London Garden*, 1880, Volume XVII., page 84: "I have a spot of peaty ground deeply trenched and filled in with brush just twenty years ago. It was then planted with Rhododendrons, Azaleas and Kalmias. Two years ago we took up all the Rhododendrons, etc., and allowed the space to go to waste, as it was to be used for bedding purposes. It had been kept thoroughly clean all the time up to the removal of the shrubs. This year a customer was anxious to get a lot of Golden Rod flowers, and upon the little spot of half an acre we cut three hundred heads, of at least five species or varieties, with stems three to four feet high. Here the seeds had lain all the time, only waiting for the sun and air to give them life." In this case we cannot be quite sure from the circumstances as recorded that seeds may not have come from surrounding sources.

As an example of the way seeds may become buried in the soil without being of great age the following case will serve:

A writer in the *Gardeners' Chronicle*, for 1856, page 6, states that in a stone quarry the excavations of the common earth worm were traced to the depth of ten or twelve feet: "At the bottom is a chamber, which generally contains quantities of small stones and seeds; of these I noticed particularly the rough "boll" of flax, the stones being a size larger than these. The cavities run from one inch to one and a half inches in diameter, the perpendicular tube or track (and chambers also) being lined by an exceeding fine black earth, like that which forms the casts on the surface; and though to common observation no seeds are apparent, whenever the bisected pipes or chambers happen to remain exposed to the weather on the face of the hard clay section for a sufficient time the whole becomes green from the growth of grasses, the seeds or germs of which must apparently have existed in the fine black earth."

Darwin, in his remarkable work on the formation of vegetable mold by means of earth worms, gives similar examples of seeds being carried into the soil by their agency.

Regarding the duration of the seeds of forest trees in the soil, Henry D. Thoreau makes the following remarks in an article on the succession of forest trees in the report of the Massachusetts Board of Agriculture for 1860: "So far from the seed having lain dormant in the soil since oaks grew there before, as many believe, it is well known that it is difficult to preserve the vitality of acorns long enough to transport them to Europe; and it is recommended in Loudon's Arboretum, as the safest course, to sprout them in pots on the voyage. The same authority states that very few acorns of any species will germinate after having been kept a year, that beech mast only retains its vital properties one year, and the black walnut seldom more than six months after it has ripened. "I have frequently found," he says, "that in November almost every acorn left on the ground had either sprouted or decayed. What with frost, drouth, moisture and worms, the greater part are soon destroyed, yet it is stated by one botanical writer that "acorns that have lain for centuries on being plowed up, have soon vegetated."

Mr. George B. Emerson, in his valuable report on the "Shrubs and Trees of Massachusetts," says of pines: "The tenacity of life in the seeds is remarkable. They will remain for many years unchanged in the ground, protected by the coolness and deep shade of the forest above them. But when the forest is removed, and the warmth of the sun admitted they immediately vegetate." "Since he does not tell us on what observation his remark is founded," says Thoreau, "I doubt its truth."

Without giving further testimony I will simply say in conclusion that few, if any, cases exist in which seeds are known to have retained their vitality over fifty years; while a large majority lose their vitality under ten years. Some kinds live the longest covered with water or buried deeply in the soil, while most kinds keep best if thoroughly dried.

A good paper on this subject, by Professor William H. Brewer, may be found in the report of the Connecticut Board of Agriculture for 1879, pages 203-221.

# III.

## DOES WHEAT TURN TO CHESS?

"And the earth brought forth grass, and herb yielding seed after his kind."—*Genesis i. 12.*

NO popular error has been more generally held in this country than that wheat will turn to chess. No other subject has, during the past fifty years, been more actively discussed in the agricultural press. There are signs, however, that interest in the question is dying out, which probably means that the better educated farmers have ceased to believe in the transmutation theory.

None of the leading agricultural periodicals now advocate this theory, and some of them decline to discuss it any longer. Nevertheless, the subject is by no means out of date. There is doubtless hardly a rural neighborhood in which one or more intelligent and successful, if not in all respects well informed, farmers do not hold to this belief. A well known botanist says, "Of all the numerous farmers' institutes which I have attended, scarcely one has adjourned without bringing up this subject. No other question has been so frequently asked." Upon taking up the last number of a prominent agricultural journal I find an article on this subject.

In a recent report from the Chicago Board of Trade I read that the price of wheat suddenly advanced, owing to reports "that the wheat in Missouri and Kansas was turning to chess." The Director of at least one of the State experiment stations holds firmly to this belief.

The causes assigned for the alleged transmutation of wheat to chess are numerous and varied: sowing shrunken seed; sowing in a certain time of the moon; injury by the Hessian fly; eating off of the plants by stock or by fowls; trampling by animals, or injury by passing vehicles; drowning or freezing out during winter; cutting off the "tap" root, in imitation of heaving during winter.

It is remarkable that in this country the belief in transmutation is confined almost wholly to the single case of the change of wheat into chess. In Europe a belief in the change of various plants into one another is common. In Sweden and in some parts of England chess is believed to be degenerated rye. The common darnel (*Lolium temulentum*) was formerly, at least, believed to be degenerated wheat by most farmers in the south of England. The name "rye grass," by which this plant is widely known, was given because of the belief in many parts of Europe that it was degenerated rye.

Tusser, in his "Five Hundred Points of Good Husbandry," says:

"Who soweth his barliè too soon or in raine,
Of otes and of thistles shal after complaine."

A writer in the *Gardeners' Chronicle* says, "How often have we heard it asserted that it is dangerous to sow Italian Rye Grass, as it is sure to turn into Couch" [Quack grass]. In some localities the various grains are supposed to be convertible into each other in a certain progressive order—wheat into rye, rye into barley, barley into rye grass, and rye grass into chess. In this free country where "belief is untramelled, even by reason," we go at one step from wheat to chess. In the English agricultural journals of a number of years ago are explicit directions for transforming one kind of grain into another. A case in which these directions were followed, apparently with more than usual care, may be given as an example:[1] "In June, 1855, a few rows of oats were dibbled in in a garden, each oat carefully noted before planting. The plants were cut down in the green state twice during the summer, and were protected from frost in the winter. Several of the stools survived the winter, and in the summer of 1856 produced several ears of perfectly formed *barley*, of thin quality, but entirely distinct

[1] Journal of Agriculture, 1861, p. 321.

from oats." This was repeatedly planted, and gradually improved, producing an improved variety of barley which was extensively cultivated.

The above experiment was performed by Mr. Elkins of Bluntisham, in Huntingdonshire. Other similar cases are recorded.

No longer ago than 1885 Mr. C. S. Read, a well known farmer, agricultural writer, and member of Parliament, stated[2] that he had known oats which were kept cut during the first year, and protected by a covering of straw during the winter, to produce the next year other kinds of grain—in one case wheat, in another rye, and in another barley. The editor of the journal in which this report is published, who is also a botanist, states, naturally enough, that he is astounded that such beliefs should still be held by persons of intelligence.

It seems incredible that anyone should have overlooked the fact that the oats, which are known to be liable to die out during winter, might have been replaced in the above experiments the next year by plants of other grain from seed contained in the straw with which the oats were covered. At least one experiment is recorded, however,[2] in which oats safely passed the winter without protection and produced a good crop of pure oats the next season.

1 *Gardeners' Chronicle*, 1885, p. 533.

2 P. Grieve, in *Gardeners' Chronicle*, 1875, p. 723.

Botanists themselves are not without responsibility for the existence of the belief in transmutation. The serious discussion concerning the origin of the cultivated oat from some of the known wild species might have led to the common belief (though it probably did not do so) among certain European peasantry that the wild oat, *Avena fatua*, is either the parent of the cultivated oat, or a degenerated form of it. The long and learned discussions concerning the possible origin of wheat from another well known wild grass, *Ægilops ovata*, probably tended to keep alive other beliefs in the transformation of one kind of grain into another. It seems that an intermediate form is found, in the vicinity of wheat fields, between the common wheat and this wild grass, which is wholly distinct from, though closely related to, wheat. For a long time this intermediate form was taken to indicate either that the wild grass was becoming converted into wheat, or that the wheat was degenerating into a wild state; in either case it was considered as evidence that the Ægilops was the original plant from which our cultivated wheats were derived. Further observation, however, has convinced botanists that this intermediate form, which has been named *Ægilops triticoides*, is neither wheat nor Ægilops, but a natural hybrid between the two. It is never found except on the borders of wheat fields, and it fails to reproduce itself, reverting when planted to one or both of its parents, generally to the wild state. It therefore furnishes no proof of the transmutation of either species into the other.

Another scientific error may be mentioned which was made by a botanist, and immediately corrected by another botanist.

Prof. Buckman[1] "believed that he had proved that in the course of cultivation *Poa aquatica* and *Glyceria fluitans*, two widely distinct species, lost their characters and became identical; that the same thing happened between the Fesques called *loliacea* and *pratensis*."

Prof. Decaisne, of Paris, at once requested specimens in corroboration of such remarkable results, and when they arrived they were, in both instances *Poa sudetica*, an already known species different from either of those named.

No better way of proving the impossibility of the conversion of wheat into chess exists than to show the distinct botanical differences between the two kinds of grain, together with some of the causes by which plants may be modified, and the limits beyond which such changes cannot go. To almost every one who studies plants as the botanist does, the different species, such as corn, oats, wheat, rye, etc., come to be seen as realities which can no more

[1] Country Gentleman, 1861, p. 321 (From *Gardeners' Chronicle*).

lose their identity than can the different species of domestic animals.

Species may be modified by climate, soil, or other causes, so that new varieties may in time arise, such as the different kinds of corn. Some species may be hybridized, producing plants or animals of intermediate character, as the hybrids between wheat and rye or between the horse and the ass. But no case has ever occurred in which any plant or animal has been converted into *another existing species*, and even if such a case could occur we should expect it to take place gradually and show intermediate stages, which in the alleged transformation of wheat into chess are never found.

Some years ago one of the editors of an agricultural paper offered $500 to any one who would produce a plant part way changed from wheat to chess, on the ground that if such changes were constantly taking place at least a single plant might be found in a transitive condition among the countless millions all over the country. But not a single claimant applied, in the face of a small penalty in the case of failure or attempted imposition. Other prizes have been offered for proof that wheat would produce chess, and such prizes have in several cases been claimed, but investigation has always shown, to the satisfaction of even the contestants, that actual proof was wanting.

Wheat and chess belong, not only to different species, but to distinct genera. The differences between them are structurally as great as those between a sheep and a horse. The difference in the form and arrangement of the head of the two plants can be observed by any one. The microscopic differences are even greater. The cells of the glumes or chaff of chess are oblique, those of wheat generally right angled. In wheat only one vein of the upper glume is bordered with stomata or breathing pores, in chess every vein. In wheat the grain in most varieties separates readily from the chaff, in chess it remains enclosed by the two inner chaffs, the same as in oats.

Chess is a well known wild plant in the Old World; wheat has never been found wild, and probably disappeared in the wild state soon after its introduction into cultivation. There are many species of Bromus, the natural genus to which chess belongs. Twelve of these are natives in the United States, besides five varieties; and twelve more species, like chess, have been introduced from the Old World. Most of these are weeds, but at least one (*Bromus unioloides*), called Rescue Grass, is a valuable winter pasture in the Southern States. About the year 1855, chess itself was widely heralded in the agricultural press, under the name of Willard's Brome Grass, as a new and valuable grass for meadow and pasture, and large quantities of the seed were sold to unsuspecting farmers in the eastern part of the United States at high prices before the fraud was discovered.

The idea that chess is not a real species, as distinct and permanent as any other grass or grain, but is only a degenerated condition of wheat, is one of those curiosities of belief for which it is hard to account. The fact that chess will grow from its own seed, and reproduce chess, has been proved many times, and can be observed by any boy or girl who has a little patience and an inquiring mind. Almost any sample of winter wheat, and particularly screenings, will furnish specimens of chess for the purpose. Select a given number of grains of chess, which may be distinguished from the grains of shrunken wheat by having hulls upon them, and plant them, one in a place, in regular rows, in moist garden soil. In a few days the fact that chess will germinate will be demonstrated to the satisfaction of any one. Next year, if the plants are allowed to remain, there will be equally good proof that chess will reproduce the fully developed chess plant; or, if it is desired to settle the question at once, let one find a stool of chess in the field, carefully dig it up, cut off the lower roots, shake gently or wash out the dirt, and examine in the center of the roots, at the base of the central stem, for the old kernel from which it grew. If he is as successful as the writer has been he will find it in nearly every case, and will have no difficulty in seeing that it is a kernel of *chess*, and not of *wheat*. Occasionally a kernel of true wheat has been found attached to the roots of chess, and has been exhibited as evidence that the chess grew from the wheat kernel. In fact, chess plants have been exhibited with *five or six* wheat kernels attached to the roots, which of itself proves that they could no more have originated the plant than that several cows could have one calf. In all such cases which have been examined, the wheat kernels were found at some distance from the base of the stem, and it has turned out that a root of a growing chess plant has merely entered an old decayed wheat kernel which existed in the soil. In such cases the old kernel has been easily separated from the root and shown to have no real connection with it, while on the other hand, the old grain from which a plant springs is always quite firmly attached. The position of the old seed upon a seedling plant may be readily studied by examining any young plant of corn or other grain. Persons have sometimes been puzzled by finding heads of wheat which bore one or more spikelets of chess, and these have been exhibited as evidence that such heads were changing to chess. One such case was exhibited before a meeting of the Michigan Horticultural Society,[1] and referred to a committee consisting of two professors, and a gentleman who is now editor of an agricultural paper. After careful examination, it was discovered that a spikelet of chess had been caught between some of the chaffs of the head of wheat and held in such position as to appear as if it grew there. The broken end of the stalk of the chess spikelet was discovered, however, and the head of wheat was found to be entire. Another similar case was sent from Indiana to the Academy of Sciences at Philadelphia. It was some time before this case could be explained, but the chairman of the committee to which it was referred[2] finally discovered that a spikelet of the wheat head had been artificially removed, and a spikelet of chess substituted and secured in place by some kind of cement. It was afterward learned that the one who sent the specimen had practiced the same trick upon others.

A partial explanation may perhaps be offered to account for the wide-spread belief that wheat will turn to chess. It will be noticed that most of the causes which are given for this supposed transformation are cases in which the wheat is injured in some way, winter-killing being the most common cause assigned. Now chess is a biennial, the same

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[1] See Report, 1884, p. 187.

[2] Proc., Philadelphia Academy, 1874, p. 163.

as winter wheat (in fact it is never found in spring wheat) and it is known to be more hardy than wheat. The fact that it grows wild, while wheat dies out unless artificially cultivated, is one indication of this. Whenever the wheat is injured, therefore, especially by the winter, any chess plants which remain have a better opportunity to develop, and if there are many present they may stool out and fill almost the whole ground. Had the wheat remained uninjured it would, by its more rapid growth, have so overshadowed or crowded the chess that the latter would have hardly been noticed. In a heavy growth of wheat chess plants have been found bearing seed when only two or three inches high. In such cases it might readily be supposed that there was no chess in the field. The fact that chess seed may remain in the ground for several years is also a source of surprise to farmers who sow pure seed and find chess in the crop. Farmers are also liable to be mistaken in thinking that they sow pure seed. It is nearly impossible to secure any winter wheat free from chess unless it is hand picked. A grain dealer of Detroit, Michigan, said that he believed that he had never seen a sample of wheat which did not contain some chess, though it was more abundant some years than others. The present system of employing migratory threshing machines renders it nearly impossible for any farmer to keep his grain entirely free from the seeds of chess and other weeds. Still, a few farmers do so, and by so doing have proved that the origin of chess is found in the seed planted, and not in the injury by winters and other causes. In some parts of England since the real character of chess has become better known this weed has become nearly exterminated.

Chess is believed by some to be the "tares" of the Bible. It is very common in the wheat of Syria and Palestine to-day. How much more reasonable to suppose, with the ancient Hebrews, that if one sows "good seed" he will reap a clean harvest, than to overlook the many ways in which the seeds of weeds may enter, and to suppose that because weeds appear in the crop they come from the seed which is intentionally sown.

# IV.

## PLANTING IN THE MOON.

"The superstitious man will not commit his seed to the earth when the soil, but when the moon, requires it."—*Wrenfels*, 1748.

I SUPPOSE no more accurate index exists of the state of intelligence in any community in modern times than the amount of reliance placed on the influence of the moon in human affairs.

Forty years ago the agricultural journals were frequently called upon to refute and expose the numerous popular superstitions regarding the influence of the moon in agriculture. Now it is rare that the subject is even alluded to, and although the number of persons is still large who are more or less guided in their operations by such beliefs, they are mainly of a class who are little influenced by published information of any kind.

Beliefs in the influence of the moon on plants and animals and upon the weather are almost world wide; they originated with the birth of astrology, and developed at a time when all the heavenly bodies were supposed each to have its peculiar influence over the affairs of men. The wisest of the Greeks and Romans gave directions for performing various operations in accordance with the different phases of the moon. Pliny could lay aside the weightier matters of law and history to teach that eggs, in order to hatch successfully, should be set in the new of the moon; that the full of the moon was the time to sow beans, and the new of the moon to sow lentils; that wheat intended for sale should be purchased in the full moon, because it will then increase in bulk and weight.

Wonderful are the effects related of the influence of the moon upon animals, and especially on the bodies and minds of men. Sanctorius, the inventor of the thermometer, held that a healthy man gained two pounds at the beginning of every lunar month, which was lost towards the close of the month. Exposure to moonlight has been supposed to be the cause of the sallow complexion of those who keep late hours. Sailors have a belief that it is particularly dangerous to sleep with the face exposed to the rays of the full moon. Horrible stories are related of the fate of those who have thoughtlessly or wantonly disregarded this danger: how persons so exposed have had their muscles distorted, their mouths drawn awry, and their features dreadfully and sometimes permanently disfigured. The numerous mental derangements, hallucinations, epileptic attacks, and similar strange maladies which have been attributed to the moon's influence have given, to this day, the name lunatics to persons suffering from serious mental disorders. Akin to the supposed influence of the moon in producing disease, is that of its effect on recovery from disease. How often even now do watchers at the bedside of the sick anxiously wait "until the moon changes" to learn the fate of the objects of their care! It is believed by some that wounds of all kinds are especially susceptible to the influence of the moon, a full moon having the tendency to prevent their healing rapidly. Similar to this is the supposed effect of moonlight on meat of all kinds, causing it to decay more quickly than it otherwise would. Fish, particularly, when hung out of doors in moonlight are thought to be rendered unwholesome thereby, and instances are recorded where persons have manifested the most alarming symptoms as the result of eating fish which had been so exposed.

Coming now to the more practical operations of the farm, we learn that pork killed in the new or increase of the moon will not shrink in the pot as it will if killed in the old of the moon. Calves or other animals born in the new of the moon may be expected to live and thrive, while if born in the old of the moon the chances are all against them. A rail fence built in the old of the moon will soon sink into the ground, while if built at any other time it will not sink. Shingles nailed upon a roof in the new of the moon will soon throw out the nails. Sheep sheared at that time will yield heavier fleeces than if sheared at other periods. Don't understand me as saying that all of these beliefs are held in any one locality or by any single individual, however "well informed." But a little observation will convince one that there are persons in almost every neighborhood whose reliance on the influence of the moon in some things is as implicit as on any of the laws of nature, while there are other people who, though they do not acknowledge or defend such beliefs, and who dislike very much to be considered superstitious, yet prefer in matters of importance to take their chances with the "signs of the moon" in their favor. Perhaps one is not entirely responsible for beliefs of this nature which he may hold, for few people are able at once to wholly banish them upon a demonstration of their falsity.

We will now notice some beliefs regarding the influence of the moon which at first sight appear to be a little more rational and better founded, and which are more generally held at the present time. There is no notion more firmly fixed in the popular mind than the influence of the moon on the weather. The following from a leading agricultural journal thirty years ago is probably true with slight modification to-day: "The influence of the moon on the weather is fully believed in probably by the large majority of our population. If the weather is foul no change is anticipated until the moon quarters. The new moon is particularly efficacious in bringing changes. This luminary also foreshadows the character of the weather by the angle at which its horns make their appearence with reference to the horizon. If the crescent holds water like a bowl, then look out for dry times. But if the crescent dips, so as to let the water out, look out for foul weather and floods."

In New England the character of a "wet moon" is fixed in the mind by the saying that it is so much inclined that one cannot hang a powder horn upon it. In some parts of the South, on the other hand, a wet moon is one which lies upon its back, and is supposed to be full of water, from which the rain is derived by its overflow.

Regarding the influence of the moon on temperature, two opinions are held, which in effect are directly opposite to each other. It is a common saying among the French country people that "The moon eats up the clouds."

There is a similar belief among sailors, who feel no danger on a stormy night if the moon is about to rise. This fact of the influence of the moon in dispersing the clouds must be due, if it be a fact, to the increased temperature caused by its rays. The apparent effect of the moon in dispersing the clouds can be easily observed on any moonlit night when the clouds are thin. At such a time the moon always appears to be shining through an open space in the clouds, though the latter may be moving rapidly. A little attention will convince any one that in such cases the light of the moon has merely illuminated the clouds and rendered them less visible, but no less real. The opposite belief regarding the effect of the moon on temperature is that moonbeams are cold. One proof of this is supposed to exist in the fact that on a clear night, when the moon is shining, plants are more liable to be injured by frost than on cloudy nights, when its "cold rays" are prevented from reaching the earth. That plants are more liable to be killed by frost on clear nights than on cloudy nights is a fact too well known to be disputed, but that the presence of the moon on clear nights has any material effect on the temperature is not established. The misapprehension in this case will be removed by considering that the effect of the radiation of heat from the earth or any other body is to lower its temperature, and that a covering of any kind, as of clouds far above the earth, or of any artificial object nearer to its suface, prevents to some extent the diminution of temperature, by retarding radiation.

The presence or absence of dew likewise depends on the influence of clouds in checking radiation. On cloudy nights little dew is formed, while on clear nights the dews are always more heavy, providing there is no wind and the weather is not cold enough for frost or is not excessively dry. The occurrence of frost on clear moonlit nights at a temperature apparently above the freezing point, has led the injury by frost under certain circumstances to be attributed to the direct malignant influence of the moon. In France the particular moon which is supposed to cause this result is called *la lune rousse* (the red moon) from the reddish brown color which the leaves of the vine and other plants assume under its supposed influence. Louis XIV, issued a royal order to men of science to determine the date of this moon, and received an answer that no such moon existed, and that the effect observed was the result of frost. Another widespread belief regarding the moon is its supposed influence on the rise and fall of the sap in trees. It matters not that there is no such rise and fall of the sap as was once supposed, the belief in some form is found in nearly all parts of the world. The forest laws of France at one time, if they do not now, prohibited the cutting of timber during the increase of the moon. German foresters were careful to observe the same rule. The explanation for this practice. given in the words of Sauer of Germany, is that the increase of the moon causes the sap to ascend in the timber, and, on the other hand, that its decrease causes the sap to descend. Timber, therefore, which is cut in the decrease of the moon will contain less sap, and hence will keep longer, than if cut in the increase of the moon. It is not easy to see, even on the supposition that this theory is correct, why a tree should contain less sap, as a rule, during the period of its descent than during its ascent. It is not strange, therefore, that the people of Cuba should have become confused and adopted the opposite idea that wood to resist the decay should be cut in the *waxing* moon. It is said to be commonly held in that island that the palm leaf thatch used for houses will last many years if cut during the increase of the moon, but only as many months if cut at any other time. One inhabitant, however, being induced by a traveler to make a trial of thatch cut at the two opposite phases of the moon confessed that he could see no difference in the result. Duhamel of France carefully tested the duration of timber cut in different stages of the moon and observed no material difference in the time of decay.

Another curious belief, which is perhaps more widely held than any other concerning the influence of the moon on plants, is that those plants which bear their edible portion above ground should be planted in the new of the moon while those whose edible part is below ground should be planted in the old or decrease of the moon.

Auguste Saint Hilaire states that in Brazil, cultivators plant during the decline of the moon all vegetables whose roots are used as food; and that, on the contrary, they plant during the increase of the moon, the sugar-cane, maize, rice, beans, etc., which bear their food upon their stalks and branches. Experiments at Martinique to test this belief showed that there was no foundation for it. Nevertheless, I have met this belief in the United States more frequently perhaps than any other, and it doubtless owes its vitality and uniformity of statement to the dash of philosophy in it which makes it easy to remember. Many a gardener has lost a good chance for sowing his onion seeds by thinking that when he has failed to get them sown in the old of the moon in March he must wait until the old of the moon in April. This belief in the necessity of planting root crops in the old of the moon, and all others in the new, is somewhat modified in the case of certain crops which are likely to be injured by *too vigorous* a growth.

Dr. Lardner stated some fifty years ago that it was an aphorism received by all gardeners and agriculturists in Europe that vegetables, plants and trees which are expected to flourish and grow with vigor should be planted, grafted, and pruned during the increase of the moon. This increase of vigor, however, may be at the expense of the fruit, and in such a case it should be checked by planting in the old of the moon. Peas, beans, squashes, etc., therefore, which are liable to run too much to vines, should be planted in the old of the moon. Thomas Tusser, in his "Five Hundred Points of Good Husbandry," expresses this belief when he says:

> "Sow peason and beans in the wane of the moon,
> Who soweth them sooner he soweth too soon;
> That they with the planet may rise,
> And flourish with bearing most plentiful wise."

Let us now briefly consider what effect, if any, the moon really does have on the affairs of our planet, especially on the growth of vegetation.

The most important influence of the moon is in the production of tides. The moon, by its nearness to the earth exerts a greater attractive force upon it than any other heavenly body. Every day, as the earth in its revolution turns first one side and then another toward the moon, the water and the atmosphere upon this side are drawn toward that body. This, in the case of the waters, produces the diurnal rise of the tides. Twelve hours later, when the same side is turned away from the moon, the attraction of the moon being in the opposite direction, the phenomenon of the ebbing tide is completed. As the moon is always present at about the same distance from the earth, and as we see the tides rise and fall daily, we can understand that the fact of the moon being "old" or "new" can have no effect upon this movement. The moon of course is just as real and substantial when it appears as the smallest crescent as when it appears at the full, so that it is difficult to see what influence it can exert, except in the amount of light which it imparts, at one time more than another.

The tides in the air and ocean, and whatever heat the moon may give, are the only visible sources of influence that the moon can have upon the weather. The effect of the tides, whatever it may be, must be very small, and its relation, if any, to the ordinary changes of the weather have never been pointed out. All we know is that certain regular currents in the air and in the ocean are affected by the tides, but neither these currents nor the tides have any known connection with the changes in the moon's appearance. The heat furnished by the moon is practically nothing; the moon being a cold body, far too cold to support life of any kind. It has been estimated that the heat accompanying the light of a full moon raises the temperature of the air exposed to its influence only one five thousandth part of a degree.

Change in temperature is the main cause of rainfall, aside from the amount of moisture present in the air, and this moisture is determined by the temperature of the air and the proximity of large bodies of water or other sources of supply. Knowing the slight effect of even the full moon on temperature, we are prepared for the idea that no mere changes in its phases can possibly have any appreciable effect on the fall of rain. Experiments made in England by Dr. Laycock as to the amount of rainfall at different phases of the moon showed little if any difference. Observations by Dr. Pendleton of Georgia, and others, have given like results. We will next notice the effect of the moon's light.

Most people are apt to overestimate the amount of light received from the moon, which, we know, is all derived, by reflection, from the sun. This arises from the power the eye has of adapting itself to different degrees of light. Still, even with this power of adaptation, probably most persons are surprised when they find how difficult it is to read a newspaper by moonlight. Dr. Wollaston has measured the light received from the moon and that given by the sun, and finds that if the latter be compared to the light of five and a half wax candles at the distance of one foot, the light of the moon would be represented by one one hundred and forty-fourth of one candle at the same distance. It is difficult for any of us to realize that there is so great a difference as this between moonlight and sunlight; yet if we recollect that upon going into a dark cellar, in which we can see at first absolutely nothing, we soon become accustomed to the darkness and are enabled to see more or less distinctly, we will learn to have less confidence in the impression of our unaided senses in matters of this kind. Now what effect, if any, has this small amount of light which comes from the moon on the growth of vegetation?

M. De Parville, of France, "in order to test a very popular belief in America," sowed various kinds of seeds, both in the new and the full moon, and found that most of the kinds, succeeded a little better when sown at the period of the full moon. These experiments were not regarded as very conclusive, but whatever advantage may have been gained by sowing at the given period was explained by the fact that the plants came up at a time when they had at the start the benefit of the full moon's light. It has, at least, been proved repeatedly that growing plants will "bend toward" moonlight as well as toward sunlight, and that blanched plants will acquire a greenish color when exposed to the moon's rays.

Prof. G. Giulj "caused vetches to germinate and spring up in a cellar entirely shut up from the light, both of the sun and moon; and the little plants were very white. Some of them were exposed for several nights to the action of the moon's rays, while others, also in full growth, were kept in complete darkness. The former acquired a green color, like that of the same plants exposed in the open air, and even to the sunlight; those, on the contrary, kept constantly protected from the light of the sun and moon were not at all colored and ultimately rotted."

The Abbé Tessier "made a great number of experiments upon etiolated plants which had become white or yellow from being kept in the dark, and observed that those exposed to the light of the moon, and kept in the dark during the day, were evidently less yellow or white than those kept in the dark day and night."

Prof. Zantedeschi repeated the experiments of these two observers, and found that after six nights' exposure to the rays of the full moon the color of etiolated plants had assumed a yellowish tint which appeared to be changing to the green color, while plants of the same kind which had been kept continually in the dark remained white. The same writer found that the light of the moon had the effect of reviving some drooping seedlings of mimosa.

While, therefore, we cannot say that the moon has absolutely no effect on vegetation, we can say that it has been proved that this effect is so small that in comparison with the numerous other influences which affect vegetation through the soil and atmosphere there is no occasion whatever for the cultivator to take it into account.

# V.

## DO VARIETIES RUN OUT?

STATED in this way, the question must be answered in the affirmative. Improved varieties of fruits, grains and vegetables are being continually produced, yet the actual advance in quality and productiveness is surprisingly slow. If every new variety which has been brought into general cultivation had been a permanent advance on all that had been known before the standard of cultivated plants must by this time have been far higher than it now is. It is impossible to doubt this. If, on the other hand, we mean, as we generally do, by this question, that varieties necessarily run out, without any visible cause, we are hardly entitled to answer the question until we have examined the possible causes of degeneration. The most important cause to which this degeneration of varieties has been attributed is that of propagation by grafts, buds, or division of the plant in some manner, instead of by seed. Knight believed that a variety propagated by grafts would run out and become inferior in fruit and sickly in tree at about the time the original tree reached its limit of life. This idea has been widely adopted and is still occasionally met with in horticultural writings. Thus a writer in the *Michigan Farmer*, for 1887, p. 3, attributes the apparent degeneration of certain standard varieties of apples to the fact that they originated some two hundred and fifty or three hundred years ago; while other varieties, such as the Baldwin which is but one hundred years old, are still grown successfully for the simple reason that they are of later origin and are supposed for this reason to have retained their original vigor. Botanists have hardly accepted the idea in this form, but they have generally held in recent years that sexual reproduction, that is, reproduction by seed, is essential to permanent vigor. It must be confessed, however, that actual proof of even this belief has hardly been offered. It is a belief which, nevertheless, has had much influence in stimulating the production of new varieties from seed. The degeneration of potatoes and their liability to the rot has been particularly attributed to their propagation from tubers instead of seed. Mr. Goodrich, of New York, was mainly actuated by this belief in his long continued experiments in the production of new varieties of potatoes from seed, particularly from the wild species, which he assumed to possess greater vigor from its not having been subjected to continuous reproduction by tubers alone. Mr. Goodrich produced some good varieties, and greatly improved the wild species, but he failed to produce any kinds capable of resisting rot, and there are those who think that if he had expended an equal amount of labor in improving the best existing varieties by seed his results would have been greater.

As to the degeneration of varieties of apples, pears, etc., there are those who doubt that it necessarily occurs, and who claim that under suitable conditions varieties of these fruits two hundred or more years old are as valuable as ever. Certainly there are some old sorts of the pear and the apple that retain their character remarkably well. Many others doubtless owe the fact that they are no longer cultivated to the production of newer varieties of greater value. Many sorts also owe their present inferiority in certain localities to changes in the soil or climate since they originated, through continued cultivation of the soil and the clearing up of the forests; or to their having been raised beyond the locality in which their excellence was first discovered. Such varieties are still often grown with success in favored localities. We have little proof, therefore, in plants propagated by grafts and similar means, that varieties necessarily, of themselves, wear out.

The case of varieties grown from seed is entirely different. Though theoretically we might expect them to be more permanent, or at least more vigorous, practically they are less stable. A few varieties, like the Winningstadt cabbage and the Long Green cucumber, have existed for many years, but most of our improved varieties of grains and vegetables are of short duration. The cause of this is two-fold. First there is its *heredity* always present tending to obliterate new varieties or their distinctive characters and bring them back to their original form. A germinating seed tends to reproduce not only the features of the plant which bore it, but also, less strongly, those of its remote ancestors. This hereditary tendency is strongest in plants which have not departed widely from their original type.

Second there is *variation* which obliterates a variety by causing it to depart still farther from the original state. Some of the causes of variation are known. High cultivation is an almost universal condition under which new varieties originate, and under which they are cultivated for the first few years. The originator naturally desires to make a new variety do its best, and the gardener or farmer is also likely to give extra care to a new variety for which he has paid a high price. Now it has been demonstrated not only that vigor induced by high cultivation and an abundance of food tends to be inherited, but that plants so treated are more apt than others to furnish improved varieties. Such treatment is therefore a legitimate method of obtaining better varieties, but it alone does not guarantee the permanence of varieties so produced, though some varieties are more inclined to be permanent than others.

Other causes of variation which may lead varieties to run out or lose their valuable and distinctive features are peculiarities of soil and climate. Dwarf early varieties of corn and peas will lose these characters and become larger and later if grown for a few years on rich black soil. A cold climate causes many plants to become dwarf in habit and more fruitful. Oats rapidly degenerate in most parts of the United States, but the remedy is not so much the introduction of new varieties as the frequent importation of fresh seed from regions better adapted to this grain.

Crossing is another cause of the degeneration of varieties. Systematic improvers of plants are careful to prevent crossing with inferior sorts. A few years of careful selection, preventing the access of pollen of inferior varieties, will generally produce an excellent sort which can be depended on to reproduce itself. When this variety, however, is carried into general cultivation, and exposed to crossing from other inferior sorts it may in a short time lose its acquired excellence.

Practically, therefore, varieties, at least those cultivated from seed, do run or wear out, but they do not necessarily do so, but on the other hand may be expected to continually improve if care is taken in their cultivation and selection. The proper course therefore, is not to drop the old varieties entirely, and thus lose the advantage already gained, but to continually improve them and use them as the basis for better varieties.

# VI.

## VAN MONS' THEORY.

VAN MONS was a professor in the university at Louvaine, Belgium, who devoted the greater part of his life to the amelioration of fruits. His nurseries contained, in 1823, no less than 2,000 seedlings of merit. He experimented mainly on pears, and succeeded in raising an immense number of varieties of high excellence. His theory, as stated by Downing, is substantially as follows:

All fine fruits are artificial products; the aim of nature in a wild state being only the production of a healthy and vigorous plant, with perfect seeds for continuing the species. It is the object of culture therefore to subdue or enfeeble this excess of vegetation; to lessen the coarseness of the tree; to diminish the size of the seeds; and to refine the quality and increase the size of the flesh or pulp.

There is always a tendency in our varieties of fruit trees to return, when propagated by seed, to the wild state. This tendency is most strongly shown in seedlings raised from *old* trees. "The older the tree of any cultivated variety of pear," says Van Mons, "the nearer will the seedlings raised from it approach a wild state, without, however, ever being able to return to that state." On the other hand, the seeds of a young fruit tree of a good sort, being itself in a state of amelioration, have the least tendency to retrograde, and are the most likely to produce improved sorts.

Again, there is a limit to perfection in fruits. When this point is reached the next generation will be more likely to produce inferior varieties than will the seeds of varieties that have not reached so high a state of development.

With these ideas in mind, Van Mons began by gathering seeds from *young* trees, without much regard to quality, except that they must be in a *state of variation;* that is to say, cultivated varieties, and not wild sorts. These he sowed in the nursery and allowed them to grow until of sufficient size to enable him to judge of their character. He then selected those which appeared most promising and allowed them to fruit, planting the seeds of their first specimens, whether of good or inferior quality, providing they were different from their parent. The next generation, treated in the same manner, came into bearing more quickly than the first; and so on, each generation coming into bearing more quickly than the preceding, and producing more perfect fruit. Van Mons found the pear to require the longest time to attain perfection, and he carried his process with this fruit through five generations, at which time nearly all of the seedlings were of great excellence, and came into bearing at three years from seed. Apples, he found, needed but four generations and peaches, cherries, plums, and other stone fruits but three.

The leading feature of his theory was that it was important to *subdue* or *enfeeble* the original nature of the tree. To this end he always gathered his fruits before fully ripe, allowed them to rot before planting the seeds, in order to refine or render less wild and harsh the next generation. In transplanting the young seedlings he cut off the tap root, and he annually shortened the leading and side branches, besides partially starving the trees by planting them only a few feet apart. All this lessened the vigor of the tree and produced, as he believed, an impression upon the nature of the seeds produced by the first crop of fruit. In order to attain the full force of these influences, and to continue without interruption the progressive variation, he allowed the trees to bear upon their own roots.

Such is Van Mons' theory and practice for the improvement of fruits. It has never been adopted in practice to any extent by others, not so much from a disbelief in its correctness as from the large amount of labor and patience required in carrying it out. The most characteristic feature of the theory; namely, that young trees produce seedlings which are more variable and of higher quality than old trees of the same varieties, has never been generally accepted by horticulturists, and probably contains but little truth. The other point, that fruits have a definite limit of perfection beyond which they cannot go and at which point their seedlings begin to deteriorate, cannot be considered as established, although it has been accepted by many. The only truth in this point seems to be, first, that highly developed varieties, if feeble, may yield seedlings which are possessed of such low vitality that they cannot be profitably grown; and, second, that improvement for the first few generations after a variety is introduced into cultivation is more rapid than afterward, so that varieties may seem to reach a limit of possible development, though they do not actually do so.

# VII.

## BUDS AND SEEDS.

THE well known fact that buds can be separated from a plant, and under certain conditions produce other plants, in a manner somewhat similar to seeds, has led many to suppose that on the original plant they lead a sort of independent existence—in fact that a plant may be considered as a colony instead of an individual, and that it leads much the same kind of life as a colony of sponges, each individual bud drawing its own support from the soil in the same manner as each individual in a sponge obtains its food from the surrounding water.

To carry out this idea the most astonishing errors concerning the structure of plants have been put forth. Thus, Erasmus Darwin, in his celebrated "Phytologia," published in 1800, says: "The bark is only an intermixture of the caudexes of the numerous buds as they pass down to shoot their radicles into the earth."

McIntosh, in his Book of the Garden, says, in speaking of the mutual influence of the stock and graft: "Since then the developments of the graft are proved to be in fact altogether uninfluenced by the stock, it may be safely asserted that the latter ought to be considered as a medium only, or vehicle, through which the vascular organs of the former pass and are conveyed into the soil, whence their spongioles and rootlets by the aid of electric agency affect the introsusception of the nutritious sap!"

Carpenter, in his "Vegetable Physiology," published in 1873, says:—"It has even occurred that a single bud at the summit of a stem has preserved its life whilst the vitality of all the others, and of the stem, has been in some manner destroyed; and that from this bud have been sent down bundles of root fibres between the bark and wood of the dead stem, which, when they have reached the ground, afforded abundant supplies of nutriment to the expanding bud; and this has subsequently grown into a perfect tree, enclosing the original dead stem within its trunk. The original root-fibres are in such a case surrounded in the ensuing year by another layer more resembling wood."

A similar error is refuted by Paxton in his Magazine of Botany, Volume III, p. 231. "Nothing," he says, "can be more erroneous than the doctrine that the buds of the graft send woody matter downwards which passes through its cellular substance into the stock and covers the wood of the stock with new wood; for every gardener knows that the graft never changes the wood of the stock."

This subject of the mutual influence of the graft and stock is treated in another chapter, and, as will there be shown, certain erroneous beliefs concerning the direct influence of the graft on the stock, as well as the supposed presence of rootlets passing down the trunk from the buds to the ground, arise from the failure to understand the fact that it is merely nourishment, and not vegetable tissue ready formed, which is conveyed from place to place in the plant. All growth takes place by the division of cells, and their increase in size, and these cells have no power to move, but are as fixed in their places as are the bricks in the wall of a building.

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# VIII.

## SEEDLESS FRUITS.

CERTAIN fruits are nearly always seedless, as the Banana and Pineapple. Some kinds of grapes are seedless, as those which form the raisins called Zante currants. Many other fruits are occasionally seedless. Strange ideas have been held regarding the cause of seedlessness in fruits, and queer methods recommended to produce this condition. A method firmly believed in from very ancient times is based on the supposition that the seed has some vital connection with the pith of the plant. Accordingly, we are told that in order to obtain seedless grapes and guavas, stoneless cherries, etc., all that is necessary is to split the stem or branch, remove the pith, and bind the parts together again. Another method for producing the same result, which occasionally appears in the newspapers, is to reverse the direction of growth by planting the tree or cutting top end down. It is needless to say that no intelligent fruit grower holds such an opinion.

The cause of seedlessness in fruits has been but little studied by botanists. Two general causes, however, will cover all cases. First, defective ovules; second, want of fertilization.

Usually, when pollen is withheld no fruit whatever comes to maturity. But there are some exceptions to this rule. The Date frequently produce fruits when no pollen-bearing plant is near; but always in such cases without seed. In the artificial fertilization of plants it frequently happens that where little pollen is applied few seeds are produced. It is probable that most cases of seedlessness are due to lack of pollen, these fruits having the unusal power of attaining more or less complete development without it.

There are other cases where seedlessness is not due to any want of pollen but to defective ovules. This often rises from excessive vigor of growth and probably in some cases to abortion of the ovules or rudimentary seeds. Hybrids, which are sometimes remarkably vigorous, are often partially or wholly seedless. The somewhat abnormal fruits of certain varieties of the orange are partly or wholly seedless. The pods of double flowers, if formed at all, are apt to have few or no seeds.

Seedlessness, though not fully understood, is probably not beyond the reach of being understood, but can doubtless be explained in a reasonable manner by sufficient study.

# IX.

## ERRORS ABOUT GRAFTING.

PLANTS, to succeed when grafted upon each other, must be in some way related, though as a rule, they do not need to be as closely related as they do for crossing. Usually, we may say that any two plants of the same family may be grafted together, while for crossing, the plants must generally be of the same genus. Thus the pear and the quince may be grafted together, but will not hybridize. The exact limits of grafting, however, are not easily defined, and depend on causes which are not understood. Why all varieties of pears, which are so closely related, do not grow equally well on foreign stocks, such as the quince and thorn, we do not know. We know the general limits of grafting only; the degree of success in each case must be determined by trial. No experienced gardener, for example, would try to graft a monocotyledon on a dicotyledon; in fact it is almost impossible to graft monocotyledons at all. The stories told therefore by the ancient Romans of dates, olives, pomegranates and oranges all growing from a single tree, may be regarded as fable. We know how such results were sometimes produced to astonish the curious. Pliny tells how old trees were hollowed out, and the stems of vines and young trees drawn up through the centre and made to emerge at the top and appear as though they were grafted there.

Another fallacy of grafting is the belief that two scions of different varieties may be split through the center and united together, and that when so united they will grow as a single stem, combining the characteristics of both varieties. Darwin quotes, without fully endorsing them, a number of cases of this kind. In one of these, two hyacinth bulbs were divided through the center and the opposite halves joined, and they were said to grow up united stems bearing both kinds of flowers. Darwin says that he has seen stems bearing two kinds of flowers, but that he has never been successful in uniting split grafts of any kind. In this country the apple called Sweet-and sour is supposed by some to have been produced by uniting the scions of sweet and sour varieties. Thomas Meehan, of Pennsylvania, tried such an experiment, and satisfied himself that it could be done. Twelve scions were prepared, consisting of one-half Greening and the other half Red Astrachan. They were grafted in the usual way and three of them grew, producing flowers and fruit somewhat intermediate between the two varieties, but so much like the Red Astrachan that it was generally believed by others that no true union of the split scions was effected.

Similar stories are often told of "graft hybrid" potatoes being produced by inserting the eyes of one variety into the tubers of another. Several varieties cultivated in England are said to have been produced in this way. The most carefully conducted experiments have generally shown, however, that each variety of tuber produces its own kind, whether grafted or not, and that when two kinds are found in the same hill they originated separately from the two sorts planted. Occasionally sports appear, differing somewhat from the variety planted, such as the White Peachblow, which is a sport or variation from the old Red Peachblow; and these cases have doubtless given rise to the stories that such results were produced by grafting.

The whole theory of graft-hybridization is undoubtedly false. It is true that varieties, especially of fruits, are more or less modified by the stock upon which they are grafted, but these changes are, as a rule, no greater or more remarkable than the changes produced by soil and climate.

It is frequently said that sweet varieties grafted on sour stock bear more acid fruit, and *vice versa*, and that in other features the fruit of the graft is intermediate in character between that proper to the stock and scion, but many such statements are exagerated or untrue. It is even reported that new varieties have been produced in this manner which have been extensively propagated. The Red Russet apple is such an example. The Blood orange is believed by many orange growers to have been produced by grafting an orange upon the pomegranate! There is much that is yet unknown regarding the mutual influence of the scion and stock, but such statements as these are put forth without proof or reason and cannot be accepted. So long as the desire for the marvelous on the part of so many is greater than the desire for the truth, such stories will be published without investigation and believed without reflection. Among the wonderful stories emanating from California, for example, is one in a recent number of the *California Fruit Grower*, which is apparently intended as a statement of fact, to the effect that "among the remarkable novelties announced in California for the season are Roses grafted upon Grape vines which are growing and blooming in Santa Cruz county!"

# X.

## ERRORS ABOUT CROSSING.

CROSS-FERTILIZATION, as a means of improving fruits and vegetables, is at present receiving considerable attention. To many persons there is a mystery about the process which has favored the adoption of erroneous ideas concerning the operation of crossing and the advantages to be derived from it. Below are some of the more prevalent of these errors.

1. That any unusual feature may be due to crossing. Nothing is more common than to attribute half-russet apples, striped or deformed oranges, etc., to cross-fertilization. Many such cases are sports, for which no cause is known; others are due to the influence of soil, climate or heredity.

2. That crossing is the principal cause of variation in fruits. Many suppose that crossing between the different varieties of apples in an orchard is the reason for their not coming true from seed. Such is not the case; our cultivated apples are mere *varieties*, and not races or species, and few of them reproduce themselves closely from seed under any circumstances.

3. That crossing always gives results intermediate between the varieties crossed. This is more or less true when the varieties themselves come true from seed, as with most kinds of wheat; but otherwise the chances of obtaining any definite result by crossing, are little greater than by raising ordinary seedlings.

4. That crossing always results in improvement. On the contrary, the surest way, in many cases, to develop a permanent and valuable variety is to avoid crossing and to bring about a gradual improvement of an existing variety by selection alone.

5. That the result of crossing can be seen the first season. Except in the case of corn, and perhaps other grains, in which the real "fruit" or covering of the seed, is but a thin skin, no change is observed the first year. The *seeds* are crossed the first year, but not the fruit or outer covering.

6. That one parent has a greater or different influence from the other. It is commonly held in this country that the plant which bears the fruit or seed contributes to the cross the size, form and hardiness of plant, and that the one which furnishes the pollen fixes the leading characters of its fruits and flowers. This is a mistake.

7. That crossing is a difficult process, requiring a great amount of scientific skill for its successful

prosecution. As a matter of fact most improved varieties obtained by crossing have been the work of practical gardeners who have had little theoretical knowledge of botany.

8. That crossing is such a simple process that a little botanical knowledge will enable any one to be immediately successful in it. On the contrary there are many sources of error and failure which nothing but experience and careful attention can fully overcome.

# XI.

## MISTAKES IN PRUNING.

IT IS a prevalent idea among persons who are not professional fruit growers, but who have a small orchard to furnish fruit for their own use, that when trees begin to fail to bear they need pruning. I have in mind an old apple orchard on gravelly soil which had gradually ceased to bear profitable crops of fruit. The land had been regularly planted to field crops as long as I could remember, in the same manner as other parts of the farm. The owner had given little attention to the trees beyond gathering the yearly crop of apples, but now that they had practically ceased to bear he saw that something must be done. Some one who wanted a job said that the trees needed pruning. So men were sent into the orchard with ladders, saws and axes, and in a short time the trees were relieved of a large portion of their tops. Lower limbs which interfered with cultivation were removed entirely. Some of these were as large as a man's leg. The branches which remained were trimmed up as high as possible and still leave a "well balanced" top. The next year the corn crop in that field was a good deal better than usual, and the trees bore a small crop of good apples. The season following, however, several of the trees were dead, and in a few years they were all gone. This is an extreme case, but it illustrates the rule that severe pruning usually does more harm than good. This injury occurs in several ways: If large limbs are removed (especially if no waterproof coating is applied to the wound) air and moisture soon permit the germs of decay to enter, and gradually the center of the tree becomes unsound. The center of the trunk is not strictly a living part of the tree, but we know that trees whose centers are decayed are usually less vigorous than others. They contain a thiner layer of sap-wood to convey nutriment, and they are probably otherwise defective.

The removal of large limbs injures the tree also by exposing the body to the rays of the sun, thus often inducing sun-scald or "bark-burn." This injury frequently invites the attacks of borers which work further damage.

An almost universal effect of pruning is the lowering of the general vitality of the tree. An apparent increase of vigor may manifest itself in the production of water-sprouts and in a somewhat greater growth on the branches which remain, but this increase is mainly temporary, and it is well established that orchard trees receive a check by excessive pruning, the same as hedge plants which are pruned for the express purpose of diminishing their vigor.

But, it may be asked, is it not sometimes necessary to check the vigor of a tree in order to induce fruitfulness? Very rarely in this country. More trees here are unfruitful from lack of moisture and fertility in the soil than from excessive vigor in the tree. Our changeable climate (cold winters and hot summers) is generally sufficient to induce fruitfulness as soon as a tree reaches a proper age.

Pruning is not only less needed in this country than in those having a milder climate, where there is a greater tendency to form wood, but it is also more injurious here. The wounds caused by pruning do not heal as readily in our severe climate as in a milder one, and the check to the tree is therefore greater, especially in the case of many of our fruit trees which are not native to this country and not fully adapted to its climate.

Pruning, of course, cannot be condemned altogether, and this much has been said merely to show that it should be practiced only when there are excellent reasons for it. Large trees, especially, should never be pruned to excess.

In rare cases the vigor and health of a tree is promoted by pruning. This occurs when the tree is partially dead and is struggling to maintain a number of lifeless branches. In such a case it may sometimes be renewed by vigorous pruning to induce the formation of thrifty shoots to take the place of the old branches. Limbs which are very feeble or partly dead are a burden to a tree, rather than a help, and had better be removed. Indeed, it is not uncommon to find whole orchards which are too far gone to be worth the effort to save them, but generally heavy fertilizing and good cultivation, together with the severe pruning of such trees as are actually dying, will work a great improvement.

The principle of promoting vigor by excessive pruning is illustrated by the renewal practice adopted with currants and other bush fruits. Stems which have become exhausted by age and fruiting are cut away, to be replaced by new stems to bear succeeding crops. This tendency to exhaust themselves by fruiting is manifested in different degrees in different kinds of plants, and the practice in pruning must correspond to the habit of the plant in each case. With blackberries and raspberries the canes are completely exhausted by one crop and are renewed naturally each year. In currants there is a tendency in this direction, and good crops can only be secured by a renewal of the bearing stems every few years. With gooseberries also there is a gain by a partial renewal occasionally. With plums and other trees that sprout there seems to be a natural tendency in the same direction after the tree has attained a moderate size. No such provision exists however in the case of apple and peach trees, and in these the only remedy for exhaustion from overbearing, aside from good care which will often be sufficient, is to renew the whole tree by planting a new one. This is systematically done by growers of peaches, and it is the only way in many cases to maintain fruitful apple orchards.

The question of pruning thus leads one to consider all the influences that affect the health of the tree.

# XII.

## EXOGENS AND ENDOGENS.

THE classification of all flowering plants into two grand divisions, called Endogens and Exogens,[1] although the most natural division in the vegetable kingdom is founded on an error regarding their structure and manner of growth. Exogens may perhaps be properly enough called outside-growers, as the term implies, since the new wood formed each year is produced on the outside of that which existed before, and next within the bark. But endogens can in no peculiar sense be termed inside-growers, since their new growth is likewise formed near the surface of the stem (which in this case is destitute of true bark) and not at the center, as is usually supposed. The difference between the structure of the stems of exogens and endogens are great, but they do not lie in the distinction implied in the names given to the two classes. Exogens, or more properly Dicotyledons (so called because they usually have two first or seed-leaves) produce their wood in wedges which lie side by side with their edge toward the pith of the plant, the different wedges

[1] Including Gymnosperms.

being separated in places by thin plates of cellular tissue called medullary rays or silver grain, which can be seen glistening upon the surface of blocks of wood which have been split radially from the bark toward the pith. Monocotyledons or Endogens on the other hand, including such plants as corn and the other grains, have their wood in the form of small fibres which pass through the softer tissues of the stem. These fibres have their soft growing portion at their centre, and after this has become old and permanent no further growth can take place. This is the main reason why such stems do not as a rule, grow so large as those of Dicotyledons, in which there is always on the outer surface of the wood beneath the bark a layer of tissue capable of further growth.

# XIII.

## ERRORS CONCERNING THE PITH.

J. C. LOUDON, in his Encyclopedia of Agriculture (first published in 1831), considers the pith to serve most probably to give some peculiar elaboration to the sap. After referring to the ancient vulgar error that the office of the pith was to generate the stone of the fruits (see chapter on seedless fruits), he quotes various other errors, which appear at least to have some reason in them. Among these is one related by Malpighi (who did not himself believe it), that the pith was analogous to the brain and heart of animals. He himself, however, believed the pith to be, like the cellular tissues, the viscera in which the sap was elaborated for the nourishment of the plant, and for the protrusion of the future buds. Magnol thought that it produced the flower and fruit, but not the wood. Du Hamel regarded it as being merely an extension of the pulp or cellular tissue, without being destined to perform any important function in the process of vegetation. But Linnæus was of opinion that it produces even the wood, regarding it not only as the source of vegetable nourishment but as being also to the vegetable what the brain and spinal marrow are to animals—the source and seat of life. Mr. Lindsay regarded it as being the seat of the irritability of the leaves of Minosa.

None of these theories are found in the writings of botanists of to-day, though among the uneducated, one still occasionally meets the belief that the "heart" is the vital part of the tree. The real office of the pith is mainly to serve as a place of storage for supplies of starch and other food materials during winter. After a stem has become old, even this service is no longer rendered, and the pith becomes more or less disorganized and is of no apparent use.

## XIV.

### ERRORS ABOUT ROOTS.

A PREVALENT error about roots is regarding the extent of their development. Few have any adequate idea of the distance to which roots reach; and when it is understood that at the extremities only of roots is their food absorbed it is readily seen that this is a subject that ought to be well understood by all who have the care of plants. In a recent newspaper article on the cultivation of onions I find it stated that land intended for onions should be plowed not to exceed six inches deep, as their roots never extend beyond that depth. I immediately went into the garden and pulled up an onion, and found, even as was said, the roots to be from four to six inches long. Upon examination, however, I discovered that the ends of most of the roots were *broken off.* I then tried again, this time using a spade, carefully digging down by the side of the plant, and tracing its roots downward, until I found that they reached to the depth of *three feet!* It is undoubtedly true that comparatively shallow culture is best for the onion; many of its roots are near the surface, and as the manure which is used requires to be assimilated during a comparatively short growing season it is placed near the surface where it will rapidly decompose. It has been shown, however, that the roots of onions are not confined to the surface soil and that the character of the subsoil is by no means unimportant. But the main reason why shallow cultivation succeeds so well with the onion is that the roots grow best in a compact soil. If deep plowing is given to improve the subsoil, and then the soil is allowed to settle a few months before the seed is sown, and shallow cultivation afterwards given the best results will be obtained. So the general practice of shallow cultivation for the onion is about right, though the explanation which attributes it to the supposed shallow rooting habit of the plant is erroneous.

A popular idea in regard to the roots of trees is that they grow outward only as far as the limbs extend. There is often some relation between the spread of the top and the lateral growth of the roots. Pear trees, which are inclined to grow upright, have roots which grow more directly downward than do the roots of apple trees, the tops of which are more inclined to spread. This relation, however, has been but little studied, and whatever truth there may be in it, it is certain that the roots of all our ordinary trees extend much farther laterally than do the branches. Perhaps it would be safe to say that the roots of trees extend on the average to a distance equal to the total height of the tree. They sometimes fall short of that limit, but often exceed it, especially in the open ground where trees do not grow as tall as in a forest. I have, in the forest, traced roots of the American Elm to a distance of one hundred and twenty feet, which was about the height of the tree. Professor Burrill tells of an elm, the roots of which filled a tile drain 450 feet away.

The depth to which roots penetrate depends very much on the character cf the soil. If it is dry and porous they extend deeper than if it is wet. Thus in a swamp the roots of trees grow mainly near the surface, and the trees are easily overturned by the wind when the surrounding trees are cut away. Such trees are liable to die whenever the swamps in which they grow are drained, while trees of the same kinds on upland thrive equally well in the drier soil. It is not, therefore, always true because certain trees are found mainly in swamps that they naturally prefer such locations. The fact that a moist soil and climate favors the formation of roots near the surface has recently been well illustrated in a comparison of the roots of forest trees in the eastern states with those of the same species growing in the west. In the east the roots grow mainly near the surface, which makes it difficult to cultivate newly cleared land for the first few years; while in Illinois and other parts of the west the roots grow so much deeper, owing to the drier summers, that the cultivation of new land is comparatively easy.

The depth to which the roots of cultivated plants extend depends also upon the structure of the soil. It is as necessary for most of the roots of a plant to be within the reach of air as it is for the leaves to have light and air. If, then, the air is prevented from entering the soil because of its being too compact, or containing too much moisture, most of the roots will remain near the surface, whereas in deep porous soils they will run deeper. In such soils the roots of clover have been found to the depth of thirteen feet, those of the parsnip twelve to fourteen feet, and those of alfalfa from twenty to thirty feet.

A few years ago the question of the importance of preserving the fibrous roots in transplanting trees was under discussion. After it became known that roots absorbed food only at or near their extremities the preservation of the smallest fibres in the removal of plants came to be considered a matter of almost essential importance. Further observation, however, showed that these fibres were easily destroyed by exposure to the air, and that during winter a large share of the smallest of them died as a natural process. Then it came to be understood that while the ultimate fibres are of the utmost value during the growing season they are of comparatively little use during the period of rest when plants are generally removed, and that therefore if the main root system is preserved in transplanting, down to roots the size of a pipe stem or less, the smaller fibres are easily restored by the plant if the soil and other conditions are favorable. The amount of care to be given to the preservation of the smaller roots in the removal of plants depends on the time of the year, the condition of the plant when it is removed, and on the amount of exposure it must necessarily undergo before it is again planted in the soil. Too many good roots can never be preserved, but the value of the smallest fibres under all circumstances has sometimes been overestimated.

# XV.

## SPONGIOLES.

THE tips of growing roots are usually covered with a mass of loose cellular tissue which was formerly called a spongiole, and was supposed to be the chief agent in the absorption of fluids from the soil. It is now known that this is not its function, and that its chief office is to protect the delicate extremity of the root as it pushes its way through the soil. In 1857, Mr. A. Trécul gave the name "pileorhiza," meaning root-cap, to this organ, which indicates its appearance and office. In 1837, Ohlert showed that if this so-called spongiole be cut off from a young root, and the wound covered with water-proof varnish, absorption takes place quite as well as before the operation; he expressed the opinion, now well established, that the chief organs of absorption are the numerous delicate hairs which occur a short distance back from the apex. The following is from the pen of Dr. W. J. Beal, of the Michigan Agricultural College, on this subject: "The tips of growing roots are often called spongioles or spongelets. Their name originated about one hundred and forty years ago, after some experiments by Senedier, Sarrabat, Carradori and others. Their experiments were inaccurate, as has been shown by repeating them. They thought they proved that the delicate extremities of roots alone absorb liquids. It has now been shown that these tips absorb but little moisture—that the root hairs are the chief absorbents. The term spongioles and their supposed functions, according to the old notion, is still found in many works of authors who ought to know better. It occurs in Wood's last edition; also in the works of Mrs. Lincoln Phelps, M. C. Cook's "Manual of Botanical Terms," Henslow's "Dictionary of Botanical Terms," McIntosh's "Book of the Garden," Thompson's "Gardener's Assistant," J. J. Thomas' "Fruit Culturist," and many others. Professor Johnson, of Yale College, remarks that in the popular sense spongioles do not exist. Dr. Asa Gray says they have no existence. Duchartre, an eminent French botanist, says 'the name spongioles is without foundation, and ought to be abandoned.'"

# XVI.

## CIRCULATION OF THE SAP.

WE do not yet know all about the circulation of the sap. The causes of its transfer are less simple than was at one time supposed. For a long time there was believed to be some analogy between the movements of the sap in plants and the circulation of the blood in the arteries and veins of animals. This view was held by Erasmus Darwin, who found in the stem of *Tragopogon scorzonera* (black salsify,) two circles of vessels, the inner of which he believed to serve for the ascent of the sap, and to correspond to the arteries of animals, and the outer to serve for its descent, and to correspond to the veins. Such views have not yet entirely disappeared. Thus Joseph W. Talbot, of Massachusetts, says in the Transactions of the Massachusetts Horticultural Society for 1879, page 13: "It will not be controverted that the crude sap ascends from the roots through the sap-wood to the extremities, terminating in the buds, and thence passes into the cambium layer. It will be remembered that the cambium layer envelopes every living part, and separates or lies between the sap-wood and the bark. In this layer all the buds originate, and all growth is made. Nothing grows outside of it except the bark. As the buds expand and form shoots, they carry their envelope, the cambium layer, with them. As in animal life there is no connection between the arteries and veins except at the extremities, so the ascending sap has no connection with the elaborated sap in the cambium except at the extremities in the buds. The leaves, which are the receptacles of the crude sap, throw off superfluous matter, and in their wonderful laboratory supply carbon and other elements from the air, preparatory to its entrance into the cambium layer, whence it passes down for the building up and nourishing the whole tree."

In "The Gardener's and Farmer's Reason Why," a book published in London, in 1860, the author, in answer to the question, What are the functions of the bark? says:

"It serves to protect the young wood from injury, and to act as a filter through which the descending juices of a plant may pass horizontally into the stem or downward to the root."

The idea that the sap passes in a definite current upward in the wood and downward between the wood and bark after being "elaborated" in the leaves is the popular belief at the present time. The familiar example of a tree continuing to live for some time after being stripped of its bark is certainly conclusive evidence that sap passes upward in the wood, while the no less familiar example of the edges of a wound growing more upon the upper than upon the lower side is regarded as equally conclusive that there is a downward current between the wood and bark.

The truth is, that there is no downward current anywhere at any time, and that the upward movement of the sap takes place in the cambium and living part of the bark as well as in the outer layers of the wood. It is also true that, except possibly for brief periods, there is never any well defined upward current, the so-called sap vessels being under ordinary circumstances filled with air. In the season of active growth, when the upward movement of sap is really most rapid, no free sap capable of flowing is found in the plant. The moisture in trees at such times all passes upward through the living cells of the cambium, and in and upon the walls of the cells and vessels of the newer layers of the wood and bark. How, then, since the only general movement is upward, does the elaborated sap reach the lower portion of the plant, even the extremities of the longest roots, and perform its part in promoting growth?

In the first place, there is no "elaborated sap" in the ordinary sense of the term as distinct from other sap. The material which forms the larger portion of the plant structure is not taken from the soil and "elaborated" or fitted for use in the leaves, but it comes directly from the air, and is changed by means of the living cells of the leaf into material capable of promoting the further growth of the plant. Various salts dissolved in the water absorbed from the soil are also essential to the growth and health of the plant, but they form a very small portion of the bulk of the living plant. The downward transfer of the carbon compounds derived from the air occurs as follows: This material, like that derived from the soil, is all in a soluble condition. When any matter which is either soluble, or in solution, is placed in a vessel containing a fluid in which it may be dissolved, it becomes in the course of time uniformly diffused through that fluid, whether any motion exists in the fluid or not. Thus, if a lump of sugar be placed, ever so carefully, in one edge of a dish of water, the whole contents of the dish will in time become equally sweetened. In just the same manner the fluid within the living plant tends continually to become uniform in character throughout. The sap in the lower part of the plant being less dense than that above, continually absorbs the denser material from the leaves, and as this material is constantly withdrawn from the sap in the process of growth, the demand for more material continues through the growing season. We now see, since the most of the solid material comes from above, why it is that the greater growth takes place upon the upper side of a wound in the trunk of a tree. The food material from the leaves which has gradually diffused downward from cell to cell, would cause the sap to be richer upon that side of the cut than it would be below. The causes which lead the sap to enter the plant, and continue to do so while it is in a growing condition, are somewhat complicated, and perhaps not yet fully understood. Two very important influences at work, however, are osmose and evaporation. If a glass tube, having its lower end covered by a membrane, be partly filled with a solution of salt, sugar, or some other material, and placed in a vessel of water, the solution will gradually pass outward into the water; but the water will also enter the tube and dilute the solution, and this will occur so rapidly that the solution will rise in the tube above the level of the water outside. Upon the same principle the moisture of the soil enters the plant and tends to dilute the sap already present, but as the evaporation which takes place from the leaves tends continually to condense this sap, a constant inflow of sap takes place from the soil. A striking illustration of the fact that the difference in density of the fluids in the plant and in the soil is one cause of the rise of sap in the plant is shown when plants are fertilized with strong liquid manure. The strength of the manure may not directly injure the plants, but its density often prevents its absorption, and as a result the plants wilt, though the roots are surrounded by the fluid. Numerous erroneous opinions concerning the circulation of the sap may be found in Kieth's "Botanical Lexicon," and for a more complete account of the causes which lead to the rise of the sap the student is referred to Sach's or one of the other modern works on physiological and structural botany.

# XVII.

## ELONGATION OF TREE TRUNKS, ETC.

TO many, it is a mystery how the tops of trees, which, when young, are within a few feet of the ground, become elevated, often fifty feet or more, when the tree has become of large size. Some have supposed that the trunk below the branches gradually lengthens in some way, carrying the top up with it. Those who will observe and reflect upon the subject, however, will readily discover that the top which appears upon a large tree is not the one which it had when it was small, but that, with the exception of the main stem, which has become the trunk, the top of the small tree has wholly disappeared, its limbs having died naturally one by one, or having been removed artificially, as other limbs were developed above. In the forest, where there is little light, and the trees are crowded by others, these lower limbs disappear rapidly, and the tree soon becomes tall, as it reaches upward after more light. In the open ground, on the other hand, where there is no obstruction, the lower limbs continue to grow, and the top remains low. In either case there is no elongation of any part of the trunk itself, and if at any time it is cut down and examined while yet sound, the remains of the first-formed limbs may still be found near the center in the form of knots at the same height at which they were originally produced. One who doubts can easily satisfy himself that the trunk itself does not elongate by the following experiment: Drive a number of nails or tacks in the smooth bark of a tree, at equal distances apart, one above the other. Measure their distance apart when first driven, and at intervals of a few months, and after the lapse of several years. To be very accurate file a line across the head of the nail or tack, so that there will be no mistake in measurement. Probably no difference will be found in the measurements from time to time. Professor Asa Gray, who suggested this test, found the measurements the same in April and at the close of the growing season in August. The trees he measured were young saplings of Magnolia, Buckeye, and Yellow-wood. A similar series of observations was made at the Iowa Agricultural College with the same results. In this connection the question will probably be asked in what parts of plants does growth in length take place? No brief answer to this question can be given that will cover all cases. In the chapter on sap circulation it was noticed that growth in diameter in our ordinary trees takes place in a narrow space between the wood and bark, where the cells are thin and soft and in the growing condition. In like manner, growth, wherever it occurs, takes place only where there is soft tissue of this character. For the security of the plant against external injury it is important that there should be as little such tissue exposed as possible, hence, there are various means of protecting the surface while in this condition, and of limiting its duration when exposed. In ordinary forest trees the usual period of expansion, during which the leaves are produced and the season's growth is formed, seldom exceeds two weeks, and this generally occurs in May or June, when there are few insect or fungus enemies about and before the weather has become hot and dry. An examination of growing twigs at this time will show that they elongate at first throughout their length, but that soon the lower portion of the season's growth begins to harden and ceases to lengthen. This fact may be shown in any young shoot of considerable length by noticing that the young leaves near the end are close together, and gradually become farther apart, as the internodes or spaces between them lengthen.

In roots the part which actually increases in length is confined to a very short space just back of the tip. It is thus protected, as has already been shown, by the root cap at the extremity, and in addition, all the growing force is concentrated here to drive the point of the root through the soil. Besides, if elongation took place for any considerable distance back from the point, the root hairs, which are the chief agents in its absorption of food, would be torn off by the pushing of the root through soil; for these reasons the growing part of roots is necessarily more restricted than that of stems, which have in the air nothing to prevent their expansion at any point. In the leaves and stems of grasses there are various ways by which the growing part is protected. In the leaves of June-grass, for example, there is a narrow space near the base of the leaf where growth takes place, so that the leaf continues to elongate, even if eaten off above. In all grasses the main growth of the stem itself takes place just above each joint, where it is protected by the sheath of the leaf.

## XVIII.

### FEEDING SQUASHES MILK.

STORIES are told, especially by English gardeners, of the production of enormous squashes, pumpkins, etc., by supplying them with water, milk, etc., by means of an opening either directly into the fruit or its stem, or through the hollow stem of an adjoining leaf. In the *Michigan Farmer* for 1861, p. 235, an account is given of a gardener who was noted for the size of the pumpkins which he raised. The "secret" of his method was to bore a hole into the pumpkin when a few weeks old, and insert a candle-wick, the other end of which was placed in a basin of water. It is altogether probable that such stories were first told by successful gardeners to their inquiring neighbors, not for the purpose of revealing, but in order to conceal their actual methods of operation; and there have at all times been those who were ready to accept such improbable statements to account for extraordinary results. I have known several attempts to verify these statements, always with negative results. In one conducted at the Iowa Experiment Station by Prof. G. E. Patrick and the writer, several pumpkin leaves, each of which adjoined a part-grown pumpkin, were cut off, leaving the long hollow stems, which were filled with milk, according to directions. They were examined frequently during some two weeks, but the milk failed to be absorbed, and settled in the tubes less than half an inch—no more than might be accounted for by direct evaporation. No one who has noticed how quickly growing pumpkins and other fruits of the kind decay when an opening is accidentally made in them will readily accept the idea that such fruits may be actually nourished by means of food introduced through such openings.

The case of the so-called "carnivorous" plants is wholly different. In these there are special arrangements for taking food by parts above ground, yet the amount which even they may acquire in this manner is always small in comparison with that which is taken up by the roots. The common Pitcher Plant was believed by Darwin to derive nourishment from the numerous dead insects which are always found in the fluid contained in their pitcher-like leaves. Mr. Peter Henderson repeated the experiments of Darwin on these plants and was unable to see that those which were supplied with an abundance of insects grew any better than those from which insects were excluded. The experiment ought to be tried again, as there are glands in the hollow pitcher which seem designed to absorb nourishment. It can hardly be doubted that the Sundew and Venus' Fly-trap do receive some benefit from the insects which they entrap in their strangely modified leaves. The common Martynia also seems to have the power of digesting and absorbing some portions of the small insects which are caught upon its numerous glandular hairs. Other even more remarkable examples are known, but in all such cases there are special glands for the preparation and absorption of the food. The ordinary surface of a plant has very little power of absorbing food of any kind except gases from the air. Even the food absorbed by the roots must be in a completely dissolved condition. Bearing these facts in mind no one can credit the stories that plants can be nourished to any visible extent by coarse food introduced directly into their growing stems or fruits—even if it were possible to do so without causing them to decay.

# XIX.

## THE HUMUS THEORY.

THE first attempt, says Dr. R. C. Kedzie, to explain the nutrition of plants was founded on the analogy of animal life; that, as an animal may live in vigorous health while feeding upon the remains of another animal, so vegetable remains, or the humus of the soil, is the principle food of plants. It was found, however, that the mere presence of humus or vegetable matter in the soil was not the sole condition of its fertility, and that some soils, such as our peaty swamps, might be composed almost entirely of humus, and yet for most plants be unproductive. Liebig, of Germany, in studying the question of plant nutrition conclusively refuted the humus theory, and proved that plants obtain their chief supply of carbon or woody material from the atmosphere.

Liebig's own theory of plant nutrition is stated by the same writer substantially as follows:

# XX.

## LIEBIG'S MINERAL THEORY.

THE only office of the soil, aside from holding the plant in place, and furnishing a supply of moisture, is to supply the ash elements of plants, that is, those materials which remain after the plant is burned.

2. The office of these mineral or ash elements is to enable the plant to assimilate the organic elements which it derives from the air; the assimilation of the carbo-hydrates (starch, woody fibre, etc.) being dependent upon the presence of the alkalies, especially potash and soda; and the capacity of the plant to form the albuminoids (gluten, etc.) being in like manner determined by the presence of phosphates.

3. That the fertilizers necessary for the production of a given crop could be determined in character and amount by burning the entire plant and analyzing the ash.

4. Therefore, if the proper mineral elements were supplied to the soil in suitable quantities, no other fertilizers would be needed. Farm-yard manure, for example, if burned, and the ashes

applied to the soil, would be as effective in promoting the growth of the crop as if supplied in the ordinary manner.

This theory, so cleverly stated by such an eminent authority, attracted immediate and widespread attention. Chemists engaged at once in the analysis of soils to determine what they contained, and in the analysis of plants to determine what they required. There appeared to be no flaw in the theory, and a new era of prosperity seemed about to open upon agriculture. Large establishments were erected for the manufacture of wheat manure, barley manure, turnip manure, etc., each adapted to the needs of the particular crop. But when these manures came to be tried in the field the result was a disastrous failure. We now know that there was a flaw in the theory, that if plants do not take up carbon from the soil they do obtain nitrogen mainly from the soil instead of from the air, and that the presence of decaying vegetable matter enables soils to withdraw from the air supplies of the much needed nitrogen for the use of plants. It is only recently that we have learned how the presence of organic matter enables the soil to accumulate the nitrogen upon which the plants may feed. It is only during the decay or fermentation of this organic matter through the agency of bacteria that this valuable material is withdrawn from the air and made available for plant food. These lowest forms of vegetable life possess the power which the higher plants do not have of absorbing nitrogen from the air. The humus or vegetable matter in the soil permits the growth of the bacteria, and these as they perish leave their accumulated nitrogen for the use of the higher plants.

## XXI.

### THE EXCRETORY THEORY.

ANOTHER erroneous theory which has been too readily accepted because of its supposed illustration of an analogy between plants and animals, is the excretory theory of roots, originated by the elder De Candolle, and elaborated and rendered still more erroneous by others. De Candolle's theory was that plants, having no power of selecting their food, absorbed everything soluble that came within reach of their roots, but afterward rejected by the same organs such portions as were not adapted to their use. Macaire afterward confirmed this theory to the satisfaction of himself and many others, and announced that the material excreted by growing roots was poisonous to other plants of the same kind, but might be harmless, or even beneficial, to plants of a different kind. Many agricultural writers at once adopted this theory as an explanation of the necessity for the rotation of crops, it being assumed that soils which have long supported plants of a given kind become poisoned for plants of that kind by the long continued accumulation of the root excretions. The value of crop rotation, or the introduction of plants of a different kind, lay in the utilization of these excreta, or at least in allowing time for them to disappear from the soil before plants of the original kind were again grown. The more the subject of crop rotation was studied, however, the more difficult it became to reconcile the observed facts to the excretory theory. It was found that on some soils the rotation of crops was unnecessary, but that the same crop might be grown year after year indefinitely. Other causes began to be discovered to account for the advantages derived by rotation of crops. Finally, Alfred Gyde, of Scotland, and others, re examined the subject of root excretion and proved that very little if any actual excretion takes place, and that what appeared to be such in former experiments consisted of the ordinary juices of the plant which had exuded from the broken roots of the plants employed in the experiments. They also proved that even this material was beneficial rather than otherwise when applied to the roots of other plants of the same kind.

These experiments were so conclusive and satisfactory that it is now generally accepted that no proper excretion from the roots of plants takes place.

Further experiments have shown, however, that many, if not all, plants exude an acid or alkaline fluid in small amount from their growing roots, but that this fluid instead of being waste material thrown off from the plant is evidently for the purpose of dissolving the food materials in the soil to prepare them for absorption by the plant. Even glass may be sensibly eaten away by this fluid exuded by delicate rootlets growing upon its surface.

## XXII.

### IS THE WALNUT POISONOUS?

THERE is a widespread belief that the walnut exerts a peculiar deleterious influence upon other vegetation growing in its vicinity. Thus the secretary of the Central Horticultural Society of France says: "Shrubs and underwood will generally thrive and flourish when planted under beech trees, but will not even live when planted under the shade of the walnut." A writer in a London forestry journal tells of a man who planted a row of walnuts on the north side of an apple orchard for a wind-break, and found that they killed the first row of apple trees. The same belief that the walnut is injurious to other vegetation is also quite prevalent in the United States. It is said that "the drip from the leaves of the walnut will poison every other plant it touches."

The following discussion upon the subject took place at a meeting of the Illinois Horticultural Society in 1874:

Mr. McWhorter: Grass grew under the walnut trees, but it had not the strength to stand up like the grass elsewhere; it was different in texture and quality; in fact the cattle would not eat it if they could get any other. The trees seemed to poison the grass.

Mr. Douglas: Where there is a large black walnut tree there generally are no other large trees close around; it seems to clear a space for itself, and kill out all its rivals.

Mr. Bryant: I planted an orchard, in one corner of which there stood a large black walnut tree, and after 20 years there was not a single apple tree standing within five rods of that walnut tree—all had died out. I think the roots are in some way poisonous to other trees.

Dr. Shroeder: The leaves of the walnut contain a great proportion of bitter stuff and they embitter the ground and make it sick. [Laughter].

I have tried to observe whether there was any truth in these statements and have been unable to see that the effect of the walnut upon adjoining vegetation is particularly different from that of other trees. The walnut is a rapid grower, forms a dense shade, and produces a large portion of its roots near the surface of the ground. Its effect in starving out and overshadowing other plants is therefore greater than that of some other trees. Similar beliefs to this regarding the walnut are held in regard to other plants. Thus Carpenter, in his celebrated work on "Vegetable Physiology," says: "A remarkable fact respecting the Ash, which seems to show that the secretions of its leaves are injurious to other plants, is that its *drip*—that is, the rain that drops from its branches,—renders the ground unproductive around it."

Without better evidence than is yet afforded it is impossible to accept these explanations to account for the injurious influence of the walnut, ash and certain other plants on surrounding vegetation. The supposition that the injury is caused by poisonous excretions or exhalations from their leaves is wholly unfounded. We must believe the cause of this injury in all cases to be the same as that by which buckwheat, hemp and other strong and rapidly growing plants are able to free the land from weeds and other vegetation, namely, the production of shade, and the extraction of moisture from the soil.

# XXIII.

## ARE HOUSE PLANTS INJURIOUS TO HEALTH?

THE custom of having plants in our houses has now become so common in this country that there appears hardly anywhere to exist a doubt in regard to the propriety of the practice. It is but a few years, however, since it was earnestly discussed whether the presence of plants in living rooms, and especially in sleeping rooms at night, was not injurious to health. The idea that plants so kept were prejudicial to the health of persons occupying the same rooms at night arose from the reported discovery that while plants absorbed the injurious carbonic acid gas from the air during the day, and gave off at the same time the life-giving oxygen, that at night the process was reversed, oxygen being absorbed and the deadly carbonic acid given off. The alternation of the process appeared natural enough; it was easy to remember, and it was accepted without further thought as scientific truth by many persons who possessed but a superficial knowledge of the actual condition of things. The danger at least seemed probable, and the prudent housekeeper preferred to take no chances, choosing to sacrifice her desire for the beautiful rather than to risk in any degree the health of her family. And so the house plants during the winter season, when they could not be exposed to the open air at night, to exhale without harm their poisonous gases, were consigned to the cellar until the following spring, thus depriving the household of their presence during the period when they were most needed.

This result led the florists, who were financially interested in the question, to further investigation. It was then found that the alternation in the exhalations of plants between the day and night was more apparent than real. They brought out the fact that it had been proved that plants would absorb in a few minutes of sunlight more carbonic acid than would be given out during the whole night. They also showed that all the plants that could be kept in a living room would not give off as much carbonic acid gas as would be given off by one person. They further pointed out the fact that persons might sleep night after night in a green house filled with growing plants without injury to their health. This fact, accompanied by the repeated explanation of what actually takes place in plant respiration, soon disabused the popular mind of the idea that plants are necessarily injurious to health. This case shows in an admirable manner that scientific evidence, clearly stated and frequently repeated, may be relied upon to dissipate erroneous beliefs, however widely they may have been adopted.

# XXIV.

## BLUE GLASS.

IN May, 1871, General J. A. Pleasanton, of Philadelphia, gave before the Philadelphia Society for the Promotion of Agriculture an account of some experiments on "the influence of the blue ray of sunlight and of the blue color of the sky in developing animal and vegetable life, in arresting disease, and in restoring health in acute and chronic disorders in human and domestic animals."

These experiments began with the building of a grapery in which every eighth row of glass in the roof was colored blue. Only a part of the glass was made of this color in order not to reduce the temperature too greatly. The blue glass was so placed, however, that all the plants in the house would receive from it rays of blue light at some time during the day. Vines placed in this house grew the first year with wonderful rapidity, and the second year produced an enormous crop of fruit.

Encouraged by this success General Pleasanton next tried the effect of blue light on domestic animals. A piggery was built with blue glass in the roof and sides, into which one half of a litter of pigs was placed, while the remainder were kept in an ordinary pen. The former lot gained during the winter twelve pounds more than the latter. A sick calf was then placed in a blue-glass pen and it recovered. A deaf and rheumatic mule was cured of his infirmities by having blue glass transoms over the door of his stall, through which the sunlight was thrown upon his neck night and morning. These experiments were widely published, and others soon added their testimony to the wonderful stimulating and curative properties of blue light. A lemon tree had a portion of its limbs exposed to light which came through some blue panes of glass, while the remainder received ordinary sunlight. The former grew with great vigor and bore a heavy crop of fruit, while the latter languished and bore no fruit. A sickly child regained its health when blue curtains were placed in the window. A lady afflicted with rheumatism and baldness was cured of both by means of a few panes of blue glass in her window. Some plants growing out of doors were wonderfully stimulated by having blue gauze stretched over them, while, strange to say, all insect enemies were thereby destroyed. Acting upon this suggestion, General Pleasanton then introduced blue glass into the windows of his house, with the result that all the flies in the room were soon dead. Such a wonderful discovery surely deserved to be patented. Accordingly application for a patent was made, and in September, 1871, an examiner from the United States Patent Office visited General Pleasanton's place in Philadelphia, inspected his experiments, convinced himself of their reliability, and a United States patent was forthwith granted, "for utilizing the natural light of the sun through clear glass, and the blue or electric solar rays transmitted through blue, purple or violet colored glass, or its equivalent, in the propagation and growth of plants and animals." In 1876, General Pleasanton's book appeared, bound in blue and printed in blue ink, in which are detailed his various experiments, together with a discussion on the agency of the electricity, present in the blue rays, in promoting life, and the testimony of many eminent persons as to the value of the new discovery and accounts of their success in the use of the same. The work at once attracted widespread attention, not only in this country but in Europe, curiosity having already been excited by the publication of his earlier experiments. In Paris the work was translated into French and its experiments repeated. Blue glass was introduced into conservatories and dwelling houses everywhere by those eager to test the new idea.

It is difficult now to read all this and resist the idea that General Pleasanton was engaged in perpetrating a huge joke upon the world. In vain did eminent scientific men attempt to show the fallacy of his reasoning and the inconclusiveness of his experiments. In vain did the *Scientific American* and other able journals repeatedly expose the "blue glass deception." There were always others ready to publish every claim that was made. To the general public one man's experiments were as good as another's. Few had the time or desire to reason closely on the subject, and in case of doubt it was easier to test the matter for one's self than to decide who was right and who wrong in the great controversy. And so the experiment was tried far and wide, and whether tested fairly or not, the wonderful results claimed from its use have not been attained, and blue glass forms no part of our present green houses or dwellings, save here and there for the purpose of ornament. The "blue-glass craze" has died out, and probably few persons will ever hear of it again.

It is well enough now to examine the subject, if we choose, and see if we can determine how much truth, if any, there was in the blue glass theory. It is the peculiar property of error that its effect is temporary. However much it may attract attention and accomplish for a time, it cannot stand against truth in single combat in the absence of excitement or self interest.

General Pleasanton's experiments were suggested by the previous experiments of others upon the same subject which had given unsatisfactory and contradictory results. Sir Isaac Newton, in 1666, had analyzed the sun's rays by means of a prism into the three primary colors, blue, yellow, and red. Sir John Herschel had studied the effects of these different rays in chemical decomposition and on vegetation. Others had tried the same thing, not only with the colored rays of the spectrum, but also with light of different colors, produced by different colored glass and liquids. The results disagreed not only with different observers, but also with the same observer in different plants; and it was also found that the effect of the blue light of the spectrum differed somewhat from that produced by blue glass or liquids.

One of the earliest and best established facts regarding the effect of light on vegetation is that its absence favors the germination of seeds. Its presence does not, however, appear to be very injurious. Professor Tracy, of Michigan, found that seeds germinated with greatest vigor in pots left uncovered, followed by those covered by blue, clear glass, red, and orange, in the order named. While the seeds, therefore, germinated much better under blue glass than under yellow glass, they germinated about equally well under colorless glass or none at all.

The effects of different kinds of light on the growth of plants are very different from their effects on the germinating seed. Growth consists of two distinct processes; first, the absorption and fixation of carbon from the air under the influence of chlorophyll; second, the transfer of this material into the plant tissues, or growth proper. In the Bulletin of the Botanical Society of France for 1886, on pages 120 and 123 of the Review, are notices of two recent experiments on these subjects; one by Bonnier and Magnin, of France, in which it was shown that the chlorophylline action (fixation of carbon) of the ultra violet rays is very feeble; the other, by Henslow, of England, showing that the rays at each end of the spectrum (red as well as violet,) were especially favorable to transpiration. Ray, of England, had long before shown that light alone caused the formation of chlorophyll. The experiment of Bonnier and Magnin also goes to show that in the light this action is most rapid, while from the experiment of Henslow we begin to understand how it is that growth, or the use of the accumulated food materials in the formation of the plant, is probably favored by darkness. Every observing farmer will tell you how rapidly his corn grows in the night, while we all know that in perpetual darkness, as in a cellar, growth, though it may be rapid, is only at the expense of material previously formed. The following additional experiments on the effect of lights of different color on vegetation are quoted in the *Horticulturist* for 1872, page 153:

"Mr. Best has studied the influence of light, heat and color on vegetation. In order to test the effect of green light on the sensitiveness of the Mimosa, he placed several plants under bell-glasses of different color, set in a warm green house. At the end of a few hours a difference was already apparent. Those subjected to green, yellow, or red light had the petioles erect, and the leaflets expanded; the blue and the violet, on the other hand, had the petioles almost horizontal, and the leaflets hanging down. In a week those placed beneath blackened glass were already less sensitive; in twelve days they were dead or dying. From that time the green ones were entirely insensitive, and in four days more were dead. At this time the plants under the other glasses were perfectly healthy and sensitive; but there was a great inequality of development among them. The white had made great progress, the red less, the yellow a little less still; the violet and the blue did not appear to have grown at all. After sixteen days the vigorous plants from the uncolored bell glass were moved to the green. In eight days they had become less sensitive; in two more the sensitiveness had almost entirely disappeared, and in another week they were all dead. Green rays of light appear to have no more influence on vegetation than complete absence of light; and Mr. Best believes, adds the *Academy*, that the sensitive plant exhibits only the same phenomenon as all plants colored green, but to an excessive degree." It is thus seen that blue light, green light and darkness are all injurious when long continued.

We know that many plants will grow in partial shade, and that some will thrive better if somewhat shaded. The experiments on colored glass taken together fail to show that blue glass is of any other advantage than as a shade, and that glass of any other color, except yellow, will serve the same purpose.

## XXV.

### PLANT DISEASES.

UNTIL within a few years the origin of the diseases of plants was considered even more mysterious than that of most diseases of animals. But it is now becoming well known that nearly all plant diseases are produced by certain other plants, usually of minute size and simple structure, which feed upon the living juices of other plants and thus bring about a diseased condition. These peculiar plants which are unable to obtain their nourishment from the soil and air, but must live upon other growing plants, are called parasites. They are nearly all destitute of green color, and belong chiefly to the lower orders of vegetation, known as fungi and bacteria. Not all fungi and bacteria, however, are parasitic and therefore injurious, for many live only on matter which is already dead, while a few kinds feed upon both dead and living material. Toadstools and lichens are well known examples of fungi which live mainly on decaying matter. The fungi found on living plants are nearly all of smaller size than these, and can rarely be seen without the aid of the microscope. On this account it was long before they came to be understood and studied, and even after they began to be familiar to botanists it was difficult for people who had never used a microscope to realize that there were plants which could be named, described and recognized, but which were wholly invisible to the naked eye, and that many of these were the sole cause of various disastrous diseases which afflicted the crops of the field and garden.

The circumstance which more than anything else has hindered the general recognition of the fact that plant diseases are chiefly caused by parasitic fungi, is that the prevalence of these diseases is largely controlled by the weather. Nearly all plant diseases, such as potato rot, wheat rust, etc., are most prevalent in hot, damp weather. Botanists soon discovered that this was due to the fact that the spores or seed-like bodies by which fungi are propagated, germinate, like ordinary seeds, most readily in such warm, damp weather, and thus spread the disease most rapidly at such times. Most other persons, however, still believed that the weather was the direct and only cause of the disease. Even when it became fully demonstrated that these plant diseases were accompanied by fungi, it was yet thought by many that the plants became first diseased and then attacked by the fungi, or at least that fungi only attacked unhealthy plants. Repeated artificial sowings of the spores upon healthy plants, however, proved that thrifty plants were usually fully as susceptible to the attacks of fungi as feeble ones, and therefore that the feebleness sometimes noticed in diseased plants may be produced by the presence of the parasitic fungus.

The remedies, therefore, for plant diseases are somewhat like those employed to rid our crops of weeds. They are all directed either toward the exclusion of the invisible germs or seed-like bodies from which the diseases originate, to the partial or complete destruction of the parasites whenever they have attacked the growing plant, or to the growth of the crop under conditions unfavorable to the parasite. The germs of some of these parasites, like certain kinds of weeds, are so universally present that they nearly always infest our crops when the proper conditions for their growth occur. This, for example, is the case with the red rust of wheat, which is found on many grasses also. The fungus which produces the potato rot, on the other hand is more rare, and even in seasons and localities favorable to rot, it often fails to make its appearance unless it has previously existed in the neighborhood. A knowledge of the habits of the fungus is necessary in each case in order to intelligently apply a remedy.

# XXVI.

## WHAT IS A SPECIES?

UNTIL within less than a generation, the almost universal idea among Christian nations regarding the different species of plants and animals upon the earth was that they were the direct products of original creation, and had existed unchanged since they first came into being upon the earth about 6,000 years ago. Any other idea as to their nature or origin was considered to be not only false, but unworthy to be entertained by those who believed in any influence of a supernatural power over the affairs of this world.

There had not been wanting, it is true, even from ancient times, those who had held to a belief in some form of developement of higher from lower beings. Lamarck, in the last century, boldly advocated this theory on scientific grounds to account for the presence of the different forms of life upon the earth. His opinions attracted but little attention, however, and it was not until the publication of Darwin's book, "The Origin of Species," in 1859, that scientific men began seriously to study the subject. The arguments presented in this book were so convincing, and showed so clearly many of the ways in which gradual changes in the characters of living beings took place, that its conclusions for the most part were accepted almost immediately by the greater part of the scientific world. No other one idea has ever done so much to stimulate investigation in all departments of natural science as this doctrine of evolution. Although there was so little hesitation on the part of the leading scientfic men at the time to adopt the essential features of the new theory, the theory itself was so important, and opened up so many new questions for consideration, that a large library would be required to contain all that has been written upon the subject since Darwin's book was published. The religious aspect of the question, which at first created alarm in the minds of many, was soon lost sight of by most of those engaged in scientific work, and now, thirty years later, it has practically ceased to be a topic of interest in the religious world, and the leading religious teachers have come to agree with the author of the book in question, that there is nothing in the idea of evolution, or the gradual development of higher from lower forms of life, to interfere with the properly interpreted teachings of the Bible.

Under the new idea of species these groups come to represent, not fixed and definite ideas, but merely assemblages of individuals agreeing between themselves in certain important particulars which separate them from other groups which have other particulars in common. The question. What is a species? can be illustrated more easily than it can be defined. Thus all plants may first be divided into two leading groups, those which produce true flowers and seeds and those which do not. The flowering plants may then be divided into those having solid, woody stems and a true bark, and those which have hollow or pithy stems without solid wood, and are destitute of bark. Among the ordinary woody plants may be found some having the petals of their flowers more or less united into a tube, and others with their petals wholly distinct. In the latter group are certain kinds which attract attention by their compound leaves, and by having flowers with one broad petal which stands up above the others, and which produce a peculiarly flattened pod. Many plants, differing in other particulars, have these three characters in common; in short, they exhibit a family likeness, and the group taken together is called the pea or bean family. In this and other families are subordinate groups, called genera, and in each genus still smaller groups, known as species. These various groups, one within another, were discovered and named for the most part, before the present belief in the origin of species became generally accepted, and the existence of this belief in no way interferes with the present system of classification. This system of classification may be compared to a tree, whose larger branches, bearing limbs of smaller and still smaller size correspond to the larger groups in the vegetable kingdom, within which groups containing still smaller groups occur. It in no way hinders the classification of the parts of a tree top into limbs, branches, boughs and twigs for us to know that every limb was first a slender twig. Neither does it interfere with the classification of plants into greater and lesser groups, as we find them, for us to believe that the present complex groups have been developed from preëxisting groups in which the differences between the members was less than they now are. How these differences arose may be seen to some extent by the variations arising in plants under cultivation. The cabbage, kale, cauliflower and kohlrabi all originated from a single wild species, which possesses none of the special features of either of these cultivated plants. It is a smooth-leaved plant, somewhat like the mustard, destitute of a distinct head of any kind. The cultivated varieties which have sprung from this wild species, would, if they had been found growing wild, have themselves been considered as distinct species; but in practice it has not been thought best to apply the term species to any forms which have been developed under cultivation.

The term species, then, is applied to the smallest distinct groups of wild plants; that is, to those groups which cannot be further subdivided into other definite groups. There may be some differences in form in the plants composing a species, but if these different forms do not exist in distinct groups by themselves, but show in the various individuals intermediate forms connecting one with another, the plants possessing such peculiarities are either unnoticed by the botanist and are called mere variations, or if they occur regularly in considerable numbers and are merely connected with the form which is considered the type by intermediate forms, they are recognized and named *varieties.* Species and wild varieties generally come true or nearly true from seed; mere variations and most cultivated varieties do not, until they have been fixed by a more or less prolonged course of selection.

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# XXVII.

## SOMETHING NEW.

"We study and investigate, not in the vain hope of acquiring knowledge, but to prevent the ignorance of others being thrust upon us."

IT may be interesting, after discussing old and exploded beliefs, to come to a subject which in name at least is new. No people equal the Americans in their eagerness to adopt new ideas, and as a result progress is nowhere more rapid in every department of effort than in this country. Incidentally, this desire for improvement leads to frequent disappointment and loss. It cannot be useless, therefore, to call attention, even briefly, to a few of the errors one is likely to make in the purchase of new seeds and plants. Ignorance is chiefly disastrous when united to self-confidence, and we know that to be forewarned is to be forearmed. Nothing is more commendable than the widespread desire among our farmers, gardeners and fruit growers to test new methods and varieties, and it is therefore highly important to prevent as far as possible unnecessary disappointments in these trials. Large sums are lost annually in the purchase of novelties in agriculture and horticulture, a considerable portion of which might be saved if the purchaser possessed a general knowledge of what it is reasonable to expect in a new variety. For want of this information it is the poor farmer as a rule, who can least afford a loss, who meets with the most disastrous failures when he does begin to experiment. These failures arise, not only from his own ignorance, but too often also from the fact that this ignorance is taken advantage of by the dishonesty of others, who induce him to purchase plants or seeds which the seller knows to be worthless. Occasionally also, it must be added, the cupidity of the buyer as well as his laudable desire for gain, is utilized by the better informed seller to his own loss.

It is no proper part of this discussion to expose or denounce fraud, and if fraudulent practices are here mentioned in connection with others it is only to show the practical difficulties to be met in the purchase of new varieties.

One of the most frequent sources of error in the purchase of plants and seeds lies in the multiplicity of names which exists. To one who has not particularly considered the subject a new name is generally supposed to mean something entirely different from anything before known. Such is rarely the case. The "types," as they are called, even of cultivated plants, are comparatively few, and different names often exist for varieties which are practically the same. These are sometimes the result of accident, but often due to the desire to reap the commercial advantage of every slight improvement. Professional growers are rarely misled by this multiplicity of names, but to others it is frequently a source of confusion and loss.

It may not be easy at all times to say when the use of a new name is justifiable and when it is not. Every decided improvement is entitled to a new designation of some sort, and those who have made the improvement, or who have this new variety for sale, are entitled to the full benefit to be derived from a new name. The public, however, have a right to say that the name shall in no way misrepresent or obscure the character of the variety, but so far as practicable shall indicate its character. The adoption of sensational names, therefore, instead of simple and appropriate ones, and the unnecessary suppression of the botanical or systematic name, is liable to create the suspicion of an intention to mislead; and this suspicion is apt to be confirmed in case the merits of the novelty are overstated. A recent example of this kind is that of the Japanese Wine Berry, a *raspberry* which had been for some time in cultivation as an ornamental plant under its botanical name. The plant was certainly entitled to a common name, but it would have been better if it had been called Japanese Raspberry, or some other simple appropriate name, instead of the misleading name, "wine berry." There is no evidence in this case of a deliberate intention to defraud, and the somewhat exaggerated claims set forth in behalf of this fruit may be reasonably attributed to well meaning enthusiasm, but any who are disappointed in growing the plant will not be slow to attribute both the over-praise and the misleading name to a desire to obscure its real character. The interests of horticulture certainly demand that occasion for such suspicion, whether justly founded or not, should always be avoided. For the individual buyer it is sufficient to say: endeavor to find out approximately, at least, the nature of the novelty before you buy. If one is dealing personally with an agent, and he declines to give this information so far as in his power it is safest not to purchase.

Another habit which, unfortunately, is still prevalent among American nurserymen and seedsmen is that of deliberately enlarging the illustrations of new fruits, etc., which are offered for sale. Notwithstanding the frequent denunciation of this practice by the horticultural press in late years, it is a custom still followed by many of our well known firms. For those who adopt such methods this is of course a moral question, and no other view of the subject is entitled to consideration, but for those liable to be misled by misrepresentations of this kind, such methods should be exposed, as a matter of business.

Another source of disappointment in the purchase of novelties, for which the seller may not be in any way responsible, arises from the fact that the treatment given by the purchaser is often not adapted to the requirements of the new plant. Many varieties require special treatment to succeed, and may be profitably grown only in a particular soil or climate; others on the contrary succeed under a wide diversity of conditions. New varieties should therefore be tried with caution, and their failure in particular cases should not be held to condemn them altogether.

Finally, there are so many who are willing to deliberately mislead in the sale of novelties in plants and seeds that it cannot be too strongly urged as a rule that such purchases should be made only of persons or firms known to be reliable. No one, however well informed, can safely disregard this rule. Frauds of this character often combine the three misleading features of an erroneous name, exaggerated merit, and exorbitant price. The following examples will illustrate this fact:

*Cinnamon Bean.* This is the common English horse bean, dipped in oil of cinnamon and sold as the seed of a rare Mexican plant. Five dollars a package has been paid by unsuspecting amateurs for these "truly wonderful" beans.

*Cocatel*, or *Lily of Mexico*. Under this name a thriving trade was conducted for a while by some New York sharpers about 1878. The Cocatel was described as a rare plant of unrivaled beauty, and the seeds were sold at three for a dollar. They proved to be those of the common okra or gumbo of the gardens.

*Blue Roses*. For several years a number of Frenchmen, with headquarters in New York, were engaged in selling various horticultural novelties, such as asparagus which could be cut in ninety days from seed, strawberries which grew upon bushes, and other equally impossible vegetable wonders. Among them were roses of an unheard-of size and fragrance, inclnding the "blue rose," which gardeners have long sought for but never found.

*American Velvet Plant*. Under this name the seed of our common mullein was at one time sold in England, in large quantities, as a rare ornamental plant. Of course the trick was soon exposed and its sale generally discontinued, although the plant still continued to be grown occasionally as a curiosity. The seeds of sorrel have also been sold in this country under a false name as those of a new ornamental plant.

*Green Valley Grass.* Under this and other names the well known Johnson Grass (*Sorghum halepense*) has been extravagantly praised, and the seed sold at correspondingly high prices. The grass is not hardy in the north, and needs to be grown with caution at the south, as when once planted in a favorable soil, it is very difficult to eradicate. It yields a large amount of rather coarse hay.

*Honey Blade Grass.* In 1859, a few years after Hungarian Grass was introduced into this country, the seed was sold at extravagant prices under the above name by certain New York and St. Louis dealers. In this case comparatively little harm was done, as the swindle was soon exposed, and the grass itself was a valuable one, with which every farmer should become acquainted.

*Willard's Brome Grass.* In the chapter on wheat turning to chess will be found an account of the introduction of chess as a forage plant under the above name. The fact that this vile weed received the endorsement of eminent agricultural writers and several leading agricultural journals shows the importance of a practical knowledge of botany to farmers and those who attempt to give agricultural information.

*Swedish Clover.* This is the common Alsike Clover which a seed-peddler in Pennsylvania has been selling at fancy prices, with the claim that it will furnish a permanent pasture on the most barren soils. It is described in nearly all the leading works on agriculture and is known to be inferior in most localities to the common red clover.

*Bohemian Oats.* This name refers not so much to a particular kind of oats as to a method of selling. It represents probably the largest seed swindle ever conducted in this country. The farmer buys the oats at, usually, ten dollars a bushel, giving his note therefor, and receiving a bond from the company, binding it to purchase back the crop, or a certain number of bushels, at a high price. The bond is worthless, and the oats grown are never called for, but the farmer's note is sold at a neighboring bank, and the sharpers disappear. Sometimes the seed oats sold are not even delivered, but usually they are. They are seldom, however, a valuable variety, and never come from Bohemia, as represented. At one time the old skinless oat was supplied under the name Bohemian oat. This is a variety occasionally grown in Europe, but of little value in this country. Generally the oats sold are obtained at a neighboring mill, and are the common oats of the region, which have been extra cleaned for the purpose. With no grain is it more important to have good seed than with the oat. In a large portion of the United States the best varieties of oats rapidly degenerate. Frequent introduction of good varieties from localities better adapted to this grain are therefore desirable, but care should be exercised to obtain them of reliable dealers.

It is well to add that notes given to the agents of the Bohemian Oat Company and similar fraudulent concerns have been declared void by the supreme courts of Michigan and one or two other States.

# APPENDIX.

THE following more or less prevalent errors it may be well here to place on record. Such of them as have the most semblance of truth, or are entertained to any considerable extent in this country at the present time, are accompanied by brief explanations.

*Fruits True to Variety.* — Fruits which are planted whole, so that the seedlings will be nourished by the whole fruit, will come true to the variety.—*Michigan Farmer*, 1849, page 267.

*How to Grow Figs.*—The peasants of France plant a certain bulb (*Scilla maritima?*) at the base of their fig trees to make them fruit better.—*Nature*, Vol. XXX, 1884, page 194.

*Nectar.*—"The superfluous saccharine matter remaining after the stamens and pistil have consumed all that they require."—Lindley and Moore, "Treasury of Botany," 1876.

*Origin of the Cabbage.*—"The Greeks have a fable that Jupiter, laboring to explain two oracles which contradicted each other, perspired, and from this divine perspiration the colewort sprang."—

Phillips "History of Cultivated Vegetables," Vol. I, page 92.

*Second Flowering of Timothy.*—It is a common belief in some localities that timothy flowers twice, and that the proper time to cut it is in its second blossom. It is difficult to understand how such an idea originated. Professor Beal, of the Michigan Agricultural College, has shown that it may be seven days from the time a head of timothy begins to blossom until the last flowers upon the head have faded, but that there are not two distinct periods.

*Apple Seeds.*—"In every perfect ripe apple," it was observed in an English publication about twenty years ago, "there will be found one or two perfectly round seeds, the others having one or more flattened sides. The round ones will produce the improved fruit, and the flat ones will produce the crab."—*Michigan Farmer*, 1855, page 53.

*Artificial Parasites.*—"Captain R. Mignan, in his 'Travels in Chaldea,' says that the Arabs slit the stems of the 'Alhagi' (*Hedysarum Alhagi*, L.,) near the ground and insert seeds of the watermelon, which germinate and grow on the roots in ground too dry for its own roots to succeed.

"Recent French pomologists assert that a pear seed can in like manner be made to germinate in a slit in a pear stock. Curious facts *if true.*"—*Gradeners' Monthly*, Vol. II, 1860, page 252.

*A Gardener's Cut.*—"In England a carpenter or barber will gravely show one how to make a *gardener's cut* so as to ensure the growth of a cutting. According to such authorities a cutting should be made so that the cut end may form a very obtuse angle." — Woodrow, "Gardening in India," 1888, page 110.

*The Seat of Vitality.*—Many persons think that there is something especially vital in the collar or neck of a plant, from the fact that most plants cut off at that point are thereby killed. The reason for this is that ordinary plants have no buds on their roots, and are therefore unable to sprout, and must ultimately die if cut off at the base of the stem.

*Potatoes Mixing in the Hill.*—It is sometimes said that two kinds of potatoes planted together in a hill will mix and form an intermediate variety. No one, so far as known, has tried to prove this by experiment, and the idea has doubtless arisen from the failure to understand the true nature of the sexes in plants. Plants mix or cross in the blossom only. Sports or variations which are not the result of crossing sometimes occur, and these may have given rise to the idea of direct mixing of tubers in the hill.

*Cactus Leaves.*—"Most of the species of this order are remarkable for the absence of leaves, of which no other traces can be found than tufts of prickles arising at regular intervals from the stem —these being the veins of the leaves, between which the parenchyma is not developed."—Carpenter, "Vegetable Physiology," page 416.

Probably most gardeners know by this time that most species of cactus have true leaves on their young shoots, but that these leaves soon fall away, and that the spines are not leaves.

*Action of Pollen.*—For a long time after the fertilization of plants was known as a fact, the actual process was not understood. A common supposition, held by Linnæus and other early botanists, was that the pollen upon its contact with the stigma, exploded and discharged its contents (which they called fovilla,) and that this possessed some subtle influence which caused the fruit and seed to come to perfection.

It is now well known that a pollen grain is somewhat like a seed, or more properly, like a spore, and that it undergoes a process of germination upon the stigma and penetrates to the rudimentary seed within, and by imparting to it a portion of its own substance enables it to develop.

*Sex in Melons.*—"A. W. Cooper, of Glynn County, Georgia, informs us that a certain gardener in his state raises better watermelons than his neighbors because he plants alternate rows of male and female melon seed. We cannot understand how a man can plant alternate rows of melons with seed obtained from the two sexes of the fruit, as no male blossom of any of the melon family ever produces fruit. The male and female flowers are always separate and distinct on the same vine, and it is only the latter which perfect fruit. There are, however, many persons who, having heard that there were two sexes of flowers in melons, think that both produce fruit, and we have heard dealers in our markets declare that they can readily pick out the different sexes in the ripened fruit. Of course, these men know nothing of botany."—*American Agriculturist*, 1887, page 422.

"*He and She*" *Squashes.*—There have recently appeared in several agricultural papers illustrations and descriptions of what are called "he and she" squashes. The former are long and pointed, and the latter short, and have a depression at the apex. It is believed that the latter always give the most and best seed. Similar differences are supposed to exist in pumpkins and other gourd fruits. This belief is quite common in some parts of the country. Of course, as remarked in the preceding paragraph, persons who hold such beliefs know nothing of botany. The female flowers of these plants are the only ones that bear fruit, and no possible difference in sex can exist in the fruits themselves.

*Flavoring Watermelons on the Vines.*—"A Georgia gentleman, we are informed by the statement now appearing in the daily newspapers, has discovered a method of flavoring watermelons while they are growing. Before the melon ripens he cuts out a slit in the stem one inch long and two-thirds through it. In this opening the extract or flavoring substance is placed, and then he closes the stem carefully, so as to keep out the air, and binds a string around it. The quantity of extract used depends upon the size of the melon. This operation is to be repeated every morning until the fruit is flavored satisfactorily. How this point is to be ascertained we are not informed. . . . This is a specimen of the trash which is going around the country under the head of 'Agricultural Information.'"—*American Agriculturist*, 1886, page 387.

*The Seeds of Clot-bur.*—In West Virginia there is a belief that the burs or fruits of this plant (*Xanthium Canadensis*) which contain two cells, with one seed in each, have the peculiar property that one of the seeds will germinate one year and the other the next, so that it takes two years to free the soil of this weed. An examination of seventy-one burs showed in thirty of them no good seeds, in eighteen both good, and in twenty-three one good and one bad.

H. W. Beecher, in his book on "Fruit, Flowers, and Farming," states that this weed is particularly hard to kill because it ripens its seed at *two different times.*

*A Remedy for Orange Scale.*—"I have just heard of a new method of destroying these insects which may be worth a trial. It is to make a cross incision in the bark, L shaped, and after rolling back the bark, dust the wound with flowers of sulphur. Wax and bind up as for budding. Years ago I found that the juice of the squash vine was a solvent of sulphur and would take it into the circulation of the plant. At all events it will cost nothing to try and will do no injury to the tree."—George F. Hollis, Consul at Cape Colony, in *Special Consular Report on Fruit Culture in Foreign Countries, 1890.*

*A Fruit Tree Invigorator.*—"A correspondent in Livingston county, New York, sends us a circular, headed 'A Revolution in Fruit Culture,' which is to be brought about by the use of a 'Fruit Tree Invigorator.' The compound is to be applied by boring a hole in the trunk of a tree, filling it with the 'Invigorator' and closing the hole tight with grafting wax, or a cork. It is claimed for the compound that: 'It so changes the flavor of the sap in the leaves and bark that the *aphis* that infest the tree is unable to subsist on the leaves, and is therefore driven off, leaving the tree unmolested to bring forth its blossoms and mature its fruit.' "—*American Agriculturist*, 1884, page 131.

*Seed Fertilizers*—Under the head of "Horticultural Myths," Woodrow, in his "Gardening in India," page 111, says that the people of that country believe that in order to obtain fine mangoes it is necessary to soak the seed in honey and water it with milk.

A few years ago a Boston fertilizer company advertised a "seed manure" which they claimed would impart wonderful vitality to the young plants, and increase the yield of the crop twenty-five per cent. Upon trial at the Iowa experiment station, no perceptible effect from its use could be observed upon the young plants. Various things have been recommended from time to time for the purpose of imparting nutriment to seeds, in order to secure more vigorous plants, but no good evidence exists that any of them are at all beneficial. Every properly developed seed appears to contain all the food the young plant can use until it becomes established in the soil. There are several substances, including chlorine and lime water, which quicken the germination of seeds, but there seems to be nothing except a proper amount of air, heat and moisture, which can in any way promote its vigor during the first stages of germination.

*Silica to Stiffen Wheat Straw.*—It has been supposed, and even taught, that the office of silica, which occurs so largely in the straw of wheat and other grains, was to stiffen it. With this idea, fertilizers have been manufactured, containing silica in a soluble form, for the pupose of affording an extra supply to prevent the lodging of grain. Such fertilizers are no longer offered for sale, as no beneficial results were derived from them, but it is still believed by many that silica is the main cause of the stiffness of straw, and that the lodging of grain on soil which is unusually rich in vegetable matter is due to the lack of silica in such soils. That there is no such lack of silica, however, in any ordinary soils is easily proved by the fact that scouring rushes which contain as high as ninety per cent. of silica, grow in the deepest swamps, where there is scarcely anything but vegetable matter, obtaining all the silica they need in solution from the water which has dissolved it from other plants and from soil over which it has passed. Although silica or sand may appear insoluble, it is in fact slightly soluble in ordinary rain-water, especially when acted upon by the roots of plants, and all the silica which plants need is readily obtained from this source, even where the amount of sand in the soil may appear small. Silica, however, is not an important ingredient in plants, and its presence in them is largely accidental. Still it is of some use, but this is not mainly for the purpose of stiffening them. Large forest trees, which require great stiffness in their stems, contain only small traces of it. In pines and other evergreens it is almost wholly confined to the leaves, where it is of no use for stiffening purposes. It has there, however, another use, namely to protect the leaves from the weather, and this appears to be its main purpose in the wheat plant, for it does not occur in greatest abundance in the stem, where most needed if it were for stiffening, but chiefly in the leaves, and especially in the chaff where it accumulates in large quantity during the ripening of the grain and serves to preserve the chaff from the effects of moisture and thus protects the grain.

*Trifacial Oranges.*—J. N. Whitner, in his "Gardening in Florida," gives the following account of this so-called composite fruit:

"It may interest the curious and inquiring to read of, and perhaps test by experiment, the production of what in some places in the East is called the 'Trifacial Orange,' in others the 'Oranger Hermaphrodite.' Mr. St. John, in his 'Travels in the Valley of the Nile,' gives the following account, says Lindley, of this very curious tree, in Boghos

Bey's garden at Alexandria: 'Here I was shown an extraordinary fruit tree, produced by an extremely ingenious process. They take three seeds, the citron, the orange, and the lemon, and carefully removing the external coating from one of them, and from one side of the two others, place the former between the latter, and binding the three together with fine grass, plant them in the earth. From this mixed seed springs a tree, the fruit of which exhibits three distinct species included in one rind, the division being perfectly visible externally, and the flavor of each compartment as different as if it had grown on a separate tree. This curious method of producing a tripartite fruit has been introduced by Boghos Joussouff from Smyrna, his native city, where it is said to have been practiced from time immemorial.'

"In confirmation of the above, the Rev. G. C. Renouard reported, while Foreign Secretary to the Royal Geographical Society, having seen the fruit of an orange and lemon combined, which had grown on a tree similarly produced. Mr. R. described the fruit as having the size and appearance of a large orange, with two or three patches of lemon stuck on it; the color, almost to the very edge of the different pieces, being distinctly that of the respective fruits; and on removing the rind, which, as in a common orange, was all of one piece, the portions beneath the lemon-colored parts had not only a considerable degree of acidity, while the orange had its proper degree of sweetness, but they were separated from their sweet neighbors by a distinct membrane, which, in some degree, accounted for their difference in taste."

The presence now and then of broad thickened stripes upon the lemon and orange has long been observed, and was attributed by Gallesio, an early Italian writer, to cross-fertilization, and many still believe it to be due to that cause. There is no proof, however, that either grafting or crossing has anything to do with it, and the appearances can only be considered as sports for which no direct cause is known. The resemblance of such a fruit to a combined orange and lemon is only fanciful, and extends no farther than the peel; the pulp is unchanged, and the thickened portion of the rind seldom corresponds with one of the cells of the pulp.

*Influence of Electricity on Plauts.*—From time to time some one having in mind the beneficial influence of electricity upon animals in certain diseases, raises the question whether it cannot be applied to stimulate the growth of plants. More than a century ago Abbé Nollet considered that he proved beyond a doubt that electricity, properly applied, accelerated the growth of vegetables. Experiments have since been reported in which benefits are said to have resulted from its use. A few years ago several such experiments were made in France. It had been noticed that certain plants throve better when near large trees, and it was assumed that this was due to electricity conducted to the soil by the trees. Iron cages were then prepared in which growing plants were placed under the influence of electricity, with apparently beneficial results. Naudin, however, in repeating these experiments, showed that the only advantage gained by certain plants in growing in such a cage, was due to the slight shade afforded and which these particular plants required. The London Horticultural Society took up the question and satisfied itself that no beneficial result could be obtained by the use of electricity on growing plants.

In the United States the subject has scarcely been heard of since the following was published by A. J. Downing in the first volume of the *Horticulturist:*

"Our readers will remember the startling account of the growth of crops under electric action, which went the rounds of our agricultural papers about a year ago. Mr. Rosse's report, read before the farmers' club in New York, in which he stated that by galvanizing a row of potatoes 200 feet long merely by putting down at one end of the row a copper plate, at the other one of zinc, and connecting both by a wire, by which he was able to dig full grown potatoes, while the ordinary rows on each side contained only half-formed tubers; and still more that of Dr. Foster, who enclosed part of a barley field in Scotland with a few poles driven into the ground in the form of a square, over which wires were stretched making a wire parallelogram eleven feet high which was connected with a similar square formed by running a wire at the base of the poles, about three inches under the soil—the result of which was stated to be the most strongly marked difference in luxuriance and product of the parts of the barley field thus acted upon by the intercepted currents of electric fluid."

These experiments were repeated in various forms by many others in Europe and the United States, uniformly without beneficial results.

A recent number of the *Youth's Companion* publishes the statement that some seeds which were soaked and then electrified gave plants which were larger and had more highly colored leaves than usual, though the yield was not affected. As no further particulars are given we must wait until the experiment is repeated before accepting this statement. Electricity, undoubtedly, has some effect on all vegetable as well as animal life. If a current of electricity is passed through a vessel of water in which growing roots are suspended the roots are said to bend toward the positive pole, or side at which the current of electricity enters. This is believed to be due to the contraction of the protoplasm or cell contents upon that side of the root. There is no evidence that the growth of the roots is affected, and no good reason to believe that plants are ever benefited by a direct application of electricity, the only effect, on their health, so far as known, being that, as with animals, they are killed or injured by a heavy discharge of electricity.

A word may be added regarding the effect of electric light on plants, which is now attracting attention. The experiments thus far conducted go to show that growth can be accelerated by means of electric light, but its effect on fruitfulness is still undetermined. The expense of this method of lighting will prevent its use in the cultivation of plants except, possibly, in rare cases.