variance with what would seem to be suggested by the nature of the operation: we allude to the plan of adjusting the bed to and from the cylinder. One of the incontrovertible laws, not to say axioms, of mechanics, is that when two parts are to be moved relatively, move that one which is easiest to move, a rule which is certainly violated in the ordinary construction of the chain-bed plan machine, for it is hardly a debatable question as to the cost and convenience of adjusting the cylinder and pressure rolls, or the bed and driving gear, in fact all the machine except the frame.

The fixed cylinder was no doubt at first used to secure convenience in belting, but to contrast this with the inconvenience of having the bed continually varying its position, as the thickness of the lumber may require, would be to choose the greater of two evils.

The durability of such machines is dependent almost entirely upon the construction of the chain, which should be of hard, close, cast iron for the traveling bars; but the stationary bars should be faced with tempered steel, not soft steel, which is even worse than soft iron. The connecting links should be of the best iron, riveted with steel.

The danger of abrasion occurs in starting a new machine, and when once begun can never be safely guarded against in the future. These machines are built as a rule 24 inches or more in width, and are used for surfacing pine boards in the lake districts of the United States, where the cost of planing is almost compensated in the reduced weight of the lumber for shipment. The enormous amount of 40,000, feet, and even 50,000 feet, has been passed through one of these machines in ten hours. To do this, two boards at once, unless very wide, are fed through. So far has this system of lumber-planing been carried, especially in Chicago, that in the transition of lumber from one railway train to another, the planing is no more, nor even so much, considered as the handling.—Boston Lumber Trade.

The Wisconsin Lumberman Publishing Co. will make a specialty of giving reliable information, by letter, to persons desiring facts, figures or opinions in relation to any matters of interest connected with lumbering affairs in Central or Northern Wisconsin.

CIRCULATION OF SAP IN TREES.

The Flow of Sap in Trees and Plants—a Lecture by Professor Clark, of Massachusetts.

The following very interesting lecture by Prof. Clark, president of the Massachusetts Agricultural College, we obtain from the Boston Cultivator.

At the conclusion of President Clark's paper, Prof. Agassiz, in a few remarks, spoke of the Agricultural College at Amherst, and said "that from this time forward it has a place among the scientific institutions of the country, if it had not before." He also said "that this one paper had amply repaid every dollar that had been spent on the college."

Prof. Clark began by speaking of the structure and growth of plants, and the theories of the early botanists, who very naturally regarded the root, the stem, and the leaf as the vital organs of the plant, and ascribed to them special functions. Thus Theophrastus said the root was the stomach of the plant designed to take up nourishment, and Malpighi compared roots to hands which, in absence of the power of locomotion, were extended for food. Linnaeus also regarded them as the mouths through which the plants were nourished. In like manner the function of the stem was simply to convey the food absorbed by the roots to the parts above it, and that of the leaf to exhale or perspire surplus moisture just like the skin of animals.

After the discovery of atmospheric gases about the beginning of the present century, it was found that the leaf inhaled carbonic acid and exhaled oxygen, which was regarded at first as a sort of respiration, and this function was then added to that of perspiration. These half truths of science concerning vegetables were accepted as satisfactory for a time. It was found, however, that a fragment of a leaf or the cutting of a stem or a root could readily be made to produce buds and plants. That a plant might be inverted, and its branches become roots, while the true roots put out leaves. So it became evident that these were not true organs, with special functions, like the lungs and stomachs of animals, but were of a complex nature, with various and under some circumstances, interchangeable offices. The earlier physiologists were impressed with the idea that some kind of circulation was necessary for the distribution of nutriment to the several parts of the plant, but they were unable to derive any theory for the explanation of growth. There has been a prevalent idea, however, for more than 100 years that the crude sap ascends in the wood, especially in the sap-wood, and that the elaborated sap descends in the bark. This seemed to be
proved by the fact, first observed by Magnok, that colored liquids absorbed by plants, rose unimpeded through the wood, but not through the bark, and also by the fact that if a ring of bark be removed from a growing stem, it ceased to increase below the ring, but formed a swelling at the edge of the bark above the ring. It was observed also that the bark of those trees, which, like the birch, bled freely from a fresh wound in the wood in the spring, was always at this season comparatively dry and free from sap.

Knights experimented upon the potato plant, and discovered that when a ring of bark was removed from the stem, no tubers were formed under ground or below the ring, but small tubers appeared in the axils of the leaves, about the ring, and the plant remained fresh and vigorous, and when the auxiliary tubers were taken off, blossomed and bore fruit. Further proof of the downward or rootward tendency of the elaborated sap is seen in the effect of ringing a fruit-bearing branch of a grape vine or pear, by which the fruit is increased in size through the abundance of nutriment, which, under ordinary circumstances, would descend to the lower part of the plant.

Prof. Ramey, of London, describes an interesting experiment performed by him on some young lilacs, which seems to prove conclusively that the crude sap rises in the wood, and the perfected sap, which is essential to the life of the plant descends only in the bark on the cambium layer just beneath it, and that it is incapable of penetrating the sap-wood or any other tissue.

The peculiar vital and organic power of the cambium is remarkably illustrated in the structure and growth of grafted trees. Every person is aware that pear trees are grown upon quince roots and that they often produce finer fruit than when cultivated as standards. This is doubtless owing to the fact that quince roots, being diminutive, furnish less water for the leaves, which thus elaborate a richer sap and a more perfectly developed wood and fruit. The apricot may be grafted on the plum, and the peach on the apricot, and the almond on the peach, and thus we may produce a tree with plum roots and almond leaves. The wood, however, of the stem, will consist of four distinct varieties, though formed from one continuous cambium layer. Below the almond and bark, we shall have perfect peach wood and bark, then perfect apricot wood and bark, and at the bottom perfect plum wood and bark. In this curious instance we see the intimate correspondence between the bark and the leaf, for if we should remove the almond branches we might cause the several sorts of wood to develop buds and leafy twigs each of its own kind. Each section of the compound stem has its seat of life in the cambium, and the cambium of each reproduces cells of its own species out of a common nutrient fluid. Thus there is seen to be a flow of crude sap upward in the wood and a flow of organizable material essential to the life of the plant proceeding from the leaf to the root through the bark and cambium layer. From this perfected sap the growth of the season is formed, and provision for the beginning of the next season's growth is also stored up, commonly in the root. As the fact of a rootward flow of elaborated sap is very generally denied at the present time, it may be well to quote a single line from the edition published in 1870, of the admiral text-book on botany by the late Prof. Henfrey, of London, which has been carefully revised by Dr. Masters. In reference to this subject he says, on page 590: "The evidence of a descent of elaborated sap is overwhelming. There is then a peculiar motion or circulation of the fluid contents of every living cell, called cyclosis, or rotation of sap, and there is a general movement of fluids upward and downward in the entire plant which may be named circulation of sap. The upward flow is vastly greater and more rapid than the downward, but the motive power in all three of the cases specified is unknown, except we rest satisfied with the old-fashioned, and to some persons unphilosophical, but nevertheless real and most wonderful, power called vital force, which in the living vegetable cell subordinates all other places. Numerous hypotheses have been advanced to account for the circulation of sap through the operation of some chemical or physical forces, but their very multiplicity exposes their unsatisfactory character."

Gren, in his Anatomy of Plants, gives an illustration to explain the ascent of sap, which reminds one of the attempt of a man to lift himself over a fence by pulling on his bootstraps. He represents a number of cells surrounding a tube or duct, and states that water, being absorbed by the cells, passes into the duct to a given height. The cell membranes then swell so as to compress the duct which forces the water a little higher. It now passes out into the empty cells above those first named; their walls are swollen by the absorption of the fluid, the duct is again compressed, and so on to the top of the tree. Malpighi was of the opinion that the contraction and expansion of air in the ducts under the influence of heat and cold pumped up the sap, but this could not be without valves to obstruct its reflex action, which do not exist, since willow or rose cuttings will grow as well with one end up as with the other. Moreover, at the period of greatest pressure, there is often no air in the tree, but every cell and duct is gorged with sap, as has been fully shown in the experiments at the college. De Saussure naturally supposed the sap vessels to be endowed with a capacity for contraction and dilatation under the influence of appropriate stimulants, and thus force up the fluid which had been absorbed by the ordinary inhibition of the spongy rootlets.

Mr. Knights, without any good reason, as-
ordered the pith rages extending from the centre to the circumference of the stem to possess irritability, and by their contraction and expansion to compress and dilate alternately the fibre vascular tissue, and so cause it to act somewhat like a force pump.

Du Petit Thomas, rejecting all mere physical forces, advanced the hypothesis that the original force is a vital one, but that in the spring, after a period of repose, the buds, under the influence of the sunshine, begins to expand, and by the absorption of sap which they exhale, create a vacuum or suction which puts the fluid in motion throughout the entire plant. Exhalation and chemical changes, then occurring, keep up the flow till the fall of the leaves in Autumn. This, however, entirely fails to account for the familiar fact that the sap is pressing into the plant with tremendous force months before there is the slightest activity in the buds. Ordinarily absorption land capillary attraction have been thought to assist in producing the phenomena of the motions of sap, though no one regards them as sufficient of themselves, since they not only lack the requisite power, but also that peculiar ability manifested by the living plant to select from the soluble materials of the soil just those substances which every species needs for its peculiar constitution.

After this general discussion concerning the circulation of sap in plants, we are prepared to consider in a very brief manner the results of a few experiments instituted for the purpose of asking the trees a few questions which the books did not satisfactorily answer.

The earliest investigations in this direction of which we have a record were begun about the year 1820 by Rev. Stephen Hales, an English clergyman, and published in a volume entitled Statistical Essays, containing vegetable statistics; or an account of some statistical experiments on the sap of vegetables; being an essay toward the natural history of vegetation. Of use to those who are curious in the culture and improvement of gardening, &c.

For the first experiment described, he took a flower-pot in which was growing a sun-flower 3½ feet in height and with a leaf surface of 39 square feet, and covered the top of the pot with sheet lead, into which he inserted a narrow glass tube to admit the air, and a wider one stopped with a cork through which he watered the plant. This pot he weighed every morning and evening for fifteen days, and as there was no way of escape for the water poured into it, except through the absorption of the roots and the exhalation from the leaves, he learned that the average amount exhaled per diem was one pound and four ounces, or about one ounce of water for two square feet of leaf surface. Similar experiments with other plants showed that a cabbage exhaled in proportion to its surface nearly twice as much as the sun-flower, or one ounce for each square foot, and that a grape-vine exhaled less than most other plants. Hence the vine rarely suffers from drought.

Nearly all modern books on vegetable physiology, in whatever language printed, have given the result of Hales' experiments as the maximum pressure attained in observations upon the ascent of sap, and the grape-vine has been generally regarded as an exceptional plant in this particular, and a kind of stumbling block in the way of speculating physiologists. To learn how far this might be true, and what were the facts concerning the spring flow of sap in our forest trees, and especially in the sugar maple, in regard to which scarcely any accurate observations had been made, we begun some investigations at the agricultural college last March, the results of which may be summarily stated as follows: The great majority of trees and shrubs do not bleed from wounds at any season of the year, and the few species in our latitude which exhibit this phenomenon all do so only when deprived of their foliage. No peculiarity of structure or habitat has yet been detected to account for this extraordinary difference among them. The soft and spongy wood of the willow or elm, which often grows in moist ground, might be deemed specially suited to absorb and pour forth water before the expansion of their leaves or flowers in spring, but the wood appears to contain scarcely any sap at that time. Of more than sixty species of trees and shrubs tested by boring a three-quarter-inch hole, usually to the depth of two inches into the sap wood near the earth, only those of the following genera showed any tendency to bleed, viz.: Betula, which includes the birches; Acer, the maples; Vitis, the vines; Ostrea, the hornbeam; Juglans, the walnuts. The genus Garga, to which belong the hickories, sometimes exudes a very little sap, and possibly the fagus, or beech, and carpinus, the hop hornbeam may do the same, though no opportunity offered of testing them satisfactorily. On the 19th of March, when the ground was still covered with snow, but free from frost, fourteen species of the common forest trees were tapped, and nearly all the species brought under observation were tapped first on the 21st of April and again on the 30th of the same month. It was discovered that each species of those which flowed had its own time of beginning, when it seemed to awake from its winter's repose; that the flow steadily increased in quantity and force, as indicated by the weight of sap and the pressure on a mercurial gauge, until it reached its maximum, and then gradually declined; and that the composition of the sap of the several species differed remarkably, according to the date of the flow, and especially the time of its beginning. The sugar maple begins to flow in November, reaching its maximum about the 1st of May. The black birch begins the last of March, attains its maximum flow about the last of April, and stops by the middle of May. The wild summer grape-vine begins to flow by
the 1st of May, arrives at its maximum flow and pressure about the 20th of May, and ceases early in June. This difference in the season of flowing is of course accompanied by a corresponding variation in temperature of the soil and atmosphere, and with the chemical composition of the sap. Thus the principal ingredient of maple sap is cane sugar, that of birch sap, grape sugar, while that of vine sap is dextrine or gum.

In regard to the circumstances which affect the flow of sap from the sugar-maple, the following results have been arrived at: A careful comparison of the daily weight of sap from several trees with the meteorological observations of the same period conclusively prove that while the general flow corresponds with the season, rising to a maximum and then declining, yet the daily and hourly flow varies with the weather. The most unfavorable weather is that which is either steadily and severely cold, or uniformly warm and foggy, while the best sap days are such as are bright and warm at mid-day, but preceded by freezing nights. Such variations of temperature as affect the flow of maple sap are most likely to occur when the ground is covered with snow, because the heat of the sun during the day cannot then accumulate to moderate the cooling influence of the night. The most probable explanation of the effect of these alterations appears to be that the outer tissues of the trees are partially emptied of their contents by the contracting influence of cold, the sap being driven into the heart-wood of the trunk and large roots. Meanwhile absorption goes on as usual underground, and thus, when relief is afforded by the heat of the sun, the sap rushes back to the surface and flows abundantly. Experiments also proved that spring sap enters and fills the heart-wood as well as the albumen. Trees tapped on the north side yielded twice as much sap as those tapped on the south side, and flowed two weeks longer. Sap flows most freely within twelve feet of the earth, and flows from both ends of a cut root. The average yield of ordinary trees in a sugar orchard is sixty pounds of sap and two pounds of sugar, but a tree in Leverett is reported to have produced 1,400 pounds of sap—probably about forty pounds of sugar. There is no good evidence that the bleeding of trees or vines has any appreciable effect upon their growth or health. It only remains to state in a few words some of the surprising results obtained by the application of mercerul gauges to the sugar maple, the black birch and the grape vine. Observations were made on one or more gauges several times daily, and occasionally every hour of the day and night, from the 1st of April to the 20th of July. A gauge was attached to the sugar maple on March 31st, which was three days after the maximum flow of sap for this species, so that further observations are required earlier in the season to complete the record and determine with certainty the maximum pressure which it exhibits in the spring. Of the record made the following facts are specially interesting: First, the mercury was subject to constant and singular oscillations, standing usually in the morning below zero, so that there was indicated a powerful suction into the tree, and rising rapidly with the sun, until the force indicated was sufficient to sustain a column of water many feet in height. Thus, at 6 a.m. on April 21st, there was a suction into the tree sufficient to raise a column of water 25.95 feet. As soon as the morning sun shone upon the tree the mercury suddenly began to rise, so that at 8:15 a.m., the pressure outward was enough to sustain a column of water 23.47 feet in height, a change represented by more than 44 feet of water. On the morning of April 22d, the change was still greater, requiring for its representation 47.42 feet of water. These extraordinary fluctuations were not attended by any peculiar state of the weather, and happened twelve days before there were any indications of growth to be detected in the buds. These observations are quite new and as yet wholly inexplicable, but will receive further attention another spring. The maximum pressure of the sap for the season was observed at 10 a.m. on April 11th, and was equal to sustaining a column of water 31.73 feet high. This was an excellent sap day considering the lateness of the season. There was noted a general correspondence between the flow of sap in other maples and the pressure on the gauge. After April 29th the mercury remained constantly below zero day and night. During May there was a uniform suction equal to about eight feet of water, and the unaccountable feature of this fact is, that though apparently produced by exhalation from the expanded leaves, it remained the same, day and night, for several weeks. In June the suction gradually lessened and finally disappeared, the mercury standing steadily at zero. The fact that exhalation from the leaves of growing plants would cause a suction capable of holding up several feet of water was discovered by Hales, but has no apparent connection with these phenomena. On the 20th of April two gauges were attached to a large black birch, one at the ground and the other thirty feet higher. The next morning at 6 o'clock the lower gauge indicated the astonishing pressure of 58.55 feet of water, and the upper one of 26.74 feet. The difference between the indications of the two gauges was thus 31.8 feet, so that they corresponded almost precisely, as if connected by a tube. In order to learn whether the same principal would prevail if the upper gauge was moved, it was raised twelve feet higher. The same correspondence continued through nearly all the observations of the season, notwithstanding the gauges were separated by 42.2 feet of close-grained birch wood. At 12:30 p.m. on April 21st a hole was bored into the tree on the side opposite to the lower gauge, and at the same level. Both gauges at once began to
show diminished pressure, while sap issued freely from the whole. In fifteen minutes one pound of sap having escaped, it was found that both gauges had fallen equal to 19.27 of water. Upon closing the hole, the gauges rose in ten minutes to their previous level, showing that the rootlets had reabsorbed in that brief period the sap which had escaped from the tree, notwithstanding the enormous pressure already existing. A stop-cock having been inserted into the hole opposite the lower gauge, it was found that the communication between it and both the gauges was almost instantaneous, which shows that the tree must have been entirely filled with sap, which exerted its pressure in all directions as freely as if standing in a cylindrical vessel 42.2 feet in height. The sap pressure continued to increase, until the 4th of May it represented a column of water 84.77 feet in height, which is nearly double the highest pressure of vegetable sap ever before recorded. The buds of the birch now began to expand, the pressure of the sap to diminish, and the oscillations of the mercury to become more decided and regular than before. The upper gauge ceased to vary on May 14th, remaining stationary at zero. The suction manifested by the birch was very little, never exceeding nine feet of water, and continued only a few days. To determine if possible whether any other force than the vital action of the roots was necessary to produce the extraordinary phenomena described, a gauge was attached to the root of a black birch tree as follows: The tree stood in most ground at the foot of the south slope of a ravine, in such a situation that the earth round it was shaded from the sun by the overhanging bank. A root was then followed from the trunk to the distance of ten feet, where it was carefully cut off one foot below the surface, and a piece removed between the cut and the tree. The end of the root, thus entirely detached from the tree, and lying in a horizontal position at the depth of one foot in the cold, damp earth, unreached by the sunshine, and for the most part unaffected by the temperature of the atmosphere, measured about one inch in diameter. To this was carefully adjusted a mercurial gauge on April 26th. The pressure at once became evident, and rose constantly, with very slight fluctuations, until at noon on the 30th of April, it has attained the unequalled height of 85.8 feet of water. This wonderful result showed that the absorbing power of living birch rootlets, without the aid of any of the numerous helps imposed upon them by ingenious philosophers, such as exhalation, dilution, oscillation and contraction, capillarity, &c., &c., was quite sufficient to account for the most essential of the curious phenomena connected with the circulation of sap. Unfortunately, in an attempt to increase the capacity of the gauge, the bark of the root was injured, and this most interesting experiment terminated. There can be little doubt that future trials, carefully conducted, with suitable apparatus, will achieve still more marvelous results.

The original experiment upon the grape vine, the story of which has come down to us through 150 years, was repeated on May 2d, and a pressure of 49.52 feet of water obtained on May 25th. This is 6½ feet higher than was observed by Hales, or than has been recorded in any of the books. The peculiar features of the pressure of the vine sap are, its lateness in the season; its apparent independence of the weather; its uniform and moderate rise day and night to its maximum; its very gradual decline to zero without any marked oscillations; and its constant and almost unvarying suction of from 4.5 to 6.5 feet of water, manifested from June 20th to July 20th, when the observations ceased.

In conclusion, we may as well admit that life is still a special force in nature, and not to be resolved by vain and ignorant man into any other sort or combination of attractions or repulsions, whether called electricity, osmose, or any other name. There is obviously need of much more investigation and definite knowledge concerning the phenomena of vegetable nutrition and development, and it may be well to remember that we are everywhere surrounded by objects for scientific research demanding our utmost talent, position and skill, but sure to give ample and profitable results to every diligent inquirer. We are often inclined to encourage ourselves to remain in ignorance and idleness by dreaming of grand opportunities for study in some far-off time or space, but let all remember what every student of nature knows full well, that within the limited circle of our vision lie concealed more mysteries than with our best endeavors we can ever solve.

THE WASTE OF FENCES.

It is certainly within the bounds of fact to state that the absolute cost of fences in the United States is equal to the value of all the live stock kept upon the farms. But, unfortunately, this vast sum does not include the annual loss arising from the waste of land consequent upon our costly system of fencing, which, including the damage done to crops by the encouragement of weeds and their encroachment upon our fields, will, doubtless, reach every year to fully six per cent. upon the cost of the fences, upon the whole, and their annual cost, may be estimated at equivalent to double the value of all our live stock. The Commissioner of the Agricultural Department, in his last monthly report, estimates the cost of fencing a farm of 100 acres in Pennsylvania, with chestnut