

VIII. *On the office of the heart wood of trees.* By T. A. Knight, Esq. F. R. S. In a Letter addressed to the Rt. Hon. Sir Joseph Banks, Bart. G. C. B. P. R. S.

Read February 5, 1818.

MY DEAR SIR,

TREES of every species, that afford timber, live many years before any portion of their alburnum becomes converted into heart wood; and vegetation proceeds with as much vigour previously to the existence of that substance, as subsequently. In the oak it is rarely seen till the seedling tree becomes nearly twenty years old; when it is readily distinguishable from the alburnum by a deeper colour, higher specific gravity, and greater hardness. The tubes also, which extend through the tree longitudinally, and are always open in the alburnum, so as freely to permit the passage of air or water, are closed in the heart wood; and the cellular substance of it has appeared, in every experiment that has come under my observation, to be incapable of conveying the ascending fluid. It does not therefore appear to execute any very important office in the vegetable economy; farther than that it obviously gives, as I have remarked in a former communication, much additional strength to the stem and branches, when these, particularly the latter, become more subject to receive injury, both from the influence of winds and gravitation, on account of the increased distance of their foliage from the points of suspension. Its mode of operation in this case

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appears, however, to be purely mechanical, and not to be in any degree dependent upon the vital power of the tree; and some writers on vegetable physiology have regarded it as a wholly lifeless substance. This opinion I have always rejected, though I was unable to adduce any decisive evidence in opposition to it; but I have now reason to believe that the heart wood becomes, during winter, in common with the alburnum and bark, a reservoir of the organizable matter which the tree expends in germination in the spring; and that the fluid sap passes abundantly into it laterally, though it does not ascend through it.

I had long previously been perfectly satisfied that every species of tree, and perennial plant, contains within itself, during winter, all the organizable matter which it employs in the formation of its first foliage, and succulent shoots, in the spring; and that it is owing to the presence or absence of such reservoir, that the lives of plants become annual, biennial, and perennial. The annual plant exhausts itself wholly in feeding its flowers and seeds: it forms no reservoir, and consequently perishes. Its vital powers are not expended, for detached parts of the same plant, and obviously possessing the same life, become perennial, if planted in such season that they cannot exhaust themselves by the production of flowers before winter. A biennial plant (the common turnip affords a good and familiar example) fills its reservoir in one season, and wholly expends it in the following, when it consequently dies, like the annual plant. In the tree, as in the biennial plant, a part of the reserved sap descends early in the spring to form new roots, whilst another portion ascends to feed its buds; but the tree also discharges laterally a large

quantity of organizable matter to generate a new layer of bark over the whole surface of its alburnum, and it thus adapts its organization to its more permanent state of existence.

The alburnum and bark of trees of some species did not appear to me to be capable of containing in winter so much organizable matter as I saw thus expended in particular cases ; and I found the thickness of both these substances to be subject to great variation in trees of the same species, and of equally vigorous growth. I also observed that the heart wood of the oak, and of other trees, always contained much uncombined soluble matter ; and that its external layers annually acquired greater specific weight and density, owing to the reception of new matter, which must, I conceived, have been conveyed into it in a fluid state. I was therefore led to ascertain what quantity of fluid is retained by the heart wood of the oak, and some other species of trees in winter ; and this enquiry appeared interesting, because it has long been well known, that very considerable chemical changes take place in the sap of trees in the spring ; and that the alburnum of trees, which are not felled before that period, is brittle, and subject to decay very rapidly. The heart wood of winter-felled oak trees was also formerly very generally supposed to be much more valuable than that of trees of the same species when felled in the spring ; and I expected to obtain some evidence in support of this opinion : for if the same fluid pervade alike the heart wood and alburnum of trees, it does not appear probable that the qualities of the one will remain unchanged, when those of the other sustain so much injury.

Pieces of the external, or last formed layer of the alburnum, and of the heart wood, were taken from the trunk (near the ground) of an oak of forty years old, and of very vigorous growth, in the first week of December. These were slowly dried in a temperature not exceeding at any time a hundred and twenty degrees; under which circumstances 1000 parts of the alburnum lost 469 parts, and an equal quantity of the heart wood 500 parts, or precisely half its weight. Upon the 24th of April, similar pieces of the alburnum and heart wood were taken from the same tree, and dried in the same manner; when 1000 parts of the alburnum lost in drying 532 parts, and an equal quantity of the heart wood 507 parts.

The alburnum and heart wood of a poplar tree of about 80 years old were subjected to similar management in December; when 1000 grains of the alburnous substance lost 535 grains, and an equal quantity of the heart wood 626 grains. On the first of March, 1000 grains of alburnum being taken from a tree of similar age and habit with the preceding, lost in drying 557 grains; and the same quantity of heart wood 684 grains. Not only the cellular substance of the heart wood, but the tubes also, which are usually quite empty in the alburnum, were perfectly filled; so that the heart wood of the poplar exhibited nearly the semi-transparency of horn; and in subsequent experience I have found that it contains nearly the same quantity of water in every part of the year.

This abundant fluid in the heart wood was some years ago first observed by M. COULOMB, when felling poplar trees in

the spring. But he conceived it to be merely the fluid, which was ascending from the earth, at that period; and he concluded from subsequent observation and experiment, in the same season of the year, and in the summer, that the sap of trees chiefly passes up in the vicinity of their medulla, through their heart wood.

M. COULOMB'S statements are, I entertain no doubt, perfectly correct; but the inferences which he, and other continental naturalists have drawn from the facts which he has stated, are, I suspect, erroneous. For I have stated in a former communication, that when I intersected the alburnum of an oak tree in winter, no symptoms of life appeared above such intersection in the ensuing spring. A similar experiment being repeated in the end of June, appeared instantly to intercept the whole of the ascending current, and the leaves of a tree, of which the heart wood remained entire, faded more rapidly than those of another tree of the same species, which was felled at the same period, and lay upon the ground. In the spring of 1816 also, upon the 1st of March, the season of M. COULOMB'S experiments, I intersected the alburnum of a poplar tree, 1000 parts of which I have stated to have contained 684 parts water, and an equal quantity of its alburnum 557 parts: yet this tree, notwithstanding the immense quantity of water (probably little less than a ton) which it contained, exhibited very feeble signs of life in the following month, though the weather continued excessively wet; and before Midsummer it was perfectly lifeless. The elongated cellular, or (as it is usually called) the fibrous texture of the alburnum, through which the sap is now, I

believe, very generally supposed to ascend, appeared to have become impervious upon the conversion of alburnum into heart wood; whilst the lateral or convergent cellular processes remained open to permit the ingress of the moving fluid, without which the heart wood could not probably long retain life.

I must therefore reject the hypothesis which assumes the ascent of the sap through the heart wood, and must believe that the fluid, which affords the organizable matter that is annually deposited in the conversion of alburnum into heart wood, and which subsequently gives greater solidity and strength to that substance, is derived from the bark; and that it passes inwards during the latter part of the summer and autumn, through the convergent cellular (or medullary) processes, to return in part through the same passages when a new layer of bark is to be formed in the spring. Under such circumstances the operation of the heart wood, when it exists in large quantity comparatively with the bark and foliage, as in sound pollard oak trees, must tend to check and diminish, rather than to promote, growth; and amongst trees of this description I have often been able readily to select such as were sound by the slowness of the growth of their branches comparatively with those of other trees of apparently the same age, which were become hollow.

Whether the heart wood of oak trees, which are deprived of their bark in the spring, and suffered to remain standing till the following winter, recover the whole, or a part of the good qualities which it loses (or is supposed to lose) in the spring, is a very interesting question. A few experiments

which I have made, lead me to think it probable, that both the alburnum and heart wood become improved in quality under such circumstances ; but I am not at present in possession of such facts as can enable me to give any decisive opinion.

I am, my dear Sir, with great regard,

sincerely yours,

T. A. KNIGHT.

Downton, Dec. 24th, 1817.