even Boyle in England had given utterance to much of the same criticisms. But the work of Vaillant found its way into France and Noguez in 1725 translated a work of Niewentyt and in 1731 Boerhaave was elected to membership in the Academy of Sciences at Paris. Nollet, in 1738, was made the incumbent of a public chair of experimental physics in Paris founded by Cardinal Fleury. It was in Italy, in Florence, however, that there existed the oldest Academy of Experimental Physics in Europe.

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SPECIAL ARTICLES

LONG-LIVED CELLS OF THE REDWOOD

THE principal features of long-lived cells in the massive stems of cacti have recently been described by the senior author.[1] Medullary cells of the tree cactus (*Carnegiea*) were seen to remain alive for periods well over a century and the results of the examination of elements of all ages indicate active enlargement during the second half of the century.

Another cactus, the melon cactus or bisnaga (*Ferocactus*), which has an ovoid-cylindrical trunk was found to include similar medullary cells of great age which, however, ceased to grow after the first decade. The development of the outer cortex as a layer several inches in thickness is of such character as to demonstrate that the cortical cells have a similar period of enlargement and survival.

In all of these cells the carbohydrate components, pentosans and hexoses progressively decrease with age. The fatty substances, or lipins and nitrogenous substances, change least.

Transformation of sugars to wall-material with consequent thickening is apparent in *Carnegiea* and in the medulla of *Ferocactus*; crystals of salts accumulate in all cases. It was notable, however, that in the cortex of *Ferocactus* the disappearance of the carbohydrates extends even to the walls, which are thinner at a hundred yards than at ten, suggesting the liquefaction and removal of pentosans. It seems probable that the only consumption or use of the lipins from these cells is of that which may be in the walls and cytoplasm, and that these substances in the nuclei are but little affected.

That ray cells may attain an age of many years in the whitish sap wood of tree trunks is implied in the writings of many authors. We can not find any definite statement of living cells in heart wood, although Strasburger's account of starch in trunks of the red beech 125 layers from the surface suggests that these cells might be alive.[2] The negative assertion that "only the outer layer of the wood composed of the more recently-formed annual rings thus contain living cells and constitutes the splint-wood" made in the 14th German edition of Strasburger's text-book of botany and found on p. 158 of the 5th English revision as translated by Lang in 1921 may be taken as a correct presentation of present knowledge of this matter.

Certain features of behavior of the trunks of the California Redwood uncovered by our study of the hydrostatics of this tree led us to examine the parenchymatous cells of the trunks. There are two different types of living cells in newly-formed secondary xylem of *Sequoia sempervirens:* wood-parenchyma cells that stand in vertical files scattered among the tracheids, and ray-parenchyma cells. As in most other woody stems, the wood-parenchyma and ray-parenchyma cells of the alburnum or whitish sapwood are living and densely packed with starch.

The change from alburnum to duramen (heartwood), macroscopically recognizable in *Sequoia* by a brownish-red coloration of the duramen, is accompanied by a disappearance of starch and protoplasts from all wood-parenchyma cells and the formation of an orange-colored resin that completely or partially fills the lumen of the wood-parenchyma cells. For this reason wood-parenchyma cells are often called resin cells. The transition from alburnum to duramen is also accompanied by a disappearance of starch from the ray-parenchyma cells but this disappearance of the starch is not always followed by death and disintegration of the protoplasts. These living ray cells of the duramen have a thin layer of cytoplasm next the wall, a conspicuous nucleus, and a large central vacuole. The ray cells may remain unchanged for a long time and we have observed ray-parenchyma 70 layers deep in the heartwood with clearly defined protoplasts and apparently normal nuclei. As the sapwood in such trees included 21–23 layers these cells were about a century old. Cells of older annual increments in these stems also appeared to be living but this could not be determined with certainty since the granular nature of the cell contents obscured the nuclei. Some trees have ray-parenchyma cells that show a granular cytoplasm and small droplets of resin shortly after the transition from duramen to

[1] D. T. MacDougal. "Growth and Permeability of Century-old Cells," *Amer. Naturalist* 60, 393–415, 1926; and Frances L. Long, "Characters of Cells attaining Great Age," *Amer. Naturalist,* September–October, 61, 385–406, 1927.

[2] Strasburger, E. "Ueber den Bau und Verrichtungen d. Leitungbahnen in den Pflanzen." Pp. 274–275. 1891.

alburnum; still others have the same behavior in ray-parenchyma and wood-parenchyma and both elements in the outermost ring of heartwood contain resin only.

The reasons for this marked variation in the behavior of ray-parenchyma cells are as yet unknown. The age of the tree does not appear to be a factor, for we have found both conditions in young and in old trees. Neither is there any sharp correlation with the environment. Trees high on the dry flanks of hills or deep in the canyons of this vicinity may have living ray cells deep in the duramen.

That these cells should survive during the pronounced changes in chemical constitution of the wood, altered composition of the sap and lessened oxygen supply is a remarkable occurrence. The nuclei undergo but little change and a superficial examination suggests consumption of the carbohydrates. The well-known abrupt diminution of starch in the rays occurs in the redwood at the stage of transition from sap to heartwood. The ratio of length of life of these cells to that of their growing period is the highest known. Full size is reached almost at once—within a few days—life may continue for a century or four thousand times the duration of the growing period. In *Carnegiea* medullary cells continue to enlarge for a century; in *Ferocactus* life continues for a period ten or twelve times the growing period which extends over a decade.

It is notable that the known long-lived cells of plants are all of the simple parenchyma type as in contrast with the highly specialized long-lived cells of the brain and heart of vertebrates.

The medullary cells of *Carnegiea* which grow for a century, as might be expected, retain their embryonic character. Those of the medulla and cortex of *Ferocactus* do not. The long-lived cells of the redwood lose their capacity for division at an early stage and play no direct part in the formation of calluses, or other regenerative action so marked in the redwood. In what way the existence of these numerous strips of living cells in the heartwood, which may reach an age of more than a century, affect the pressures and movements of liquids and gases in this tree is yet to be determined. The facts presented seem to constitute the first announcement of living cells in heartwood, as well as an extension of knowledge of the occurrence and behavior of long-lived cells.

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GLUCOSE AS AN ANTAGONIST

FOR some years the senior author has been engaged in the study of the habits and means of control of the onion root maggot (*Hylemyia antiqua* Meig.). Experiments have included extensive investigation of the chemotropic responses of the flies to various substances. Cane molasses has always proved a very satisfactory attractant and NaCN has long been known and used as an effective insect poison. In consequence, a mixture composed of ¼ ounce of NaCN, 1 pint of molasses, and 1 gallon of water, was included among the various poisoned baits it was desired to test.

In the summer of 1925, Mr. K. Stewart, working on the same problem, found that the NaCN-molasses bait gave very satisfactory results, ranking first of all the materials tried in the average daily catch of Diptera. These records were obtained by the use of wire fly-traps of the Minnesota type placed in the onion fields on the College farm, with the various poison baits in glass dishes under the traps.

The NaCN-molasses combination, as one of the most promising of the mixtures under trial, was selected by the senior author for further experimentation in 1926. It continued to give very satisfactory results so far as the catch of flies was concerned, but some doubt was experienced as to the extent to which this mixture was acting as a killing agent. Accordingly, cage experiments were started indoors in order to settle this point. It was found that while the NaCN combination was even *more* attractive to the flies than molasses and water alone, its toxicity was practically nil. Upon uncorking a bottle of the mixture which had been well shaken and then allowed to stand for several days, a distinct odor of ammonia was noticed, while that of HCN could no longer be detected. Moistened litmus paper gave the alkaline color reaction when held near the mouth of the bottle. Apparently, the $-CN$ group had been decomposed, giving rise to ammonia, the evolution of which gas no doubt explains the enhanced attractiveness to the flies of the poisoned bait over that of a simple molasses-water solution.

The most probable explanation of the production of ammonia in the above mixture appears to be that of interaction between the NaCN and the glucose of the molasses to yield glucose cyanhydrin, which subsequently hydrolyzes, as follows:

$$NaCN + H_2O \leftrightarrows NaOH + HCN$$

$$CH_2OH(CHOH)_4 \cdot CHO + HCN \leftrightarrows CH_2OH(CHOH)_4 \cdot CH(OH)CN$$

$$CH_2OH(CHOH)_4 \cdot CH(OH)CN + H_2O \leftrightarrows CH_2OH(CHOH)_5 \cdot COOH + NH_3$$