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A COLCHICINE SUSCEPTIBILITY GRADIENT IN ONION ROOT-TIPS<sup>1</sup>

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It was recognized by Levan<sup>1</sup> in 1938 that the results of the action of colchicine on meristematic, somatic tissues are not necessarily a uniform polyploidy. He states that after the treatment, on onion root-tips, there is "a decided correlation between the chromosome number of a cell and the position of the cell in the root." The cells of higher ploidy were found in the proximal parts of the meristem. Thereafter, the distal meristem was progressively reconstituted to the diploid number, possibly by a differential division rate which favored the proliferation of diploid cells. Such a phenomenon might account in part for some of the technical difficulties which are encountered in the use of colchicine in the artificial production of polyploid plants.

On the basis of chance observations on the occurrence of normal mitoses in colchicine treated material, an investigation was undertaken to determine whether or not there was an orderly, regular differential reaction of different parts of the onion root to the action of colchicine.

Colchicine effects polyploidy through an inhibition of the action of the mitotic spindle. Although the centromere split is relatively delayed, the chromosomal processes go ahead as far as an initial, apparently autonomous separation of the chromatids. The centromere does finally split but there is no anaphase movement and the doubled number of chromosomes is included in a single restitution nucleus. The name c-mitosis has been adopted for this process. It is easily characterized by the failure of coorientation and congression, the absence

of spindle fibers in fixed material, and the appearance of separated chromatids joined at a conspicuous centromere.<sup>3,4</sup>

Bulbs of the yellow onion, (*Allium cepa*), were germinated in tap water. After roots one to two centimeters long had appeared, the water was replaced with an aqueous solution of colchicine (Colchicine Alkaloid, amorphous, Mallinckrodt) at concentrations of 1/1005 - .005 %. After a given time of immersion in this solution the root tips were fixed in Karpachenko or Bouin, dehydrated through dioxan, mounted in para fin, and cut longitudinally at 8 microns. The sections were then stained with Iron Haematoxylin, Newton's Violet, or Feulgen.

It soon appeared that mitoses and c-mitoses can exist in the same root tip, but their relative distribution is not random. Invariably, mitoses were found in the distal, c-mitoses in the proximal portion of the root. The zones of mitosis and of c-mitosis are so distinct as to leave no doubt as to the reality of this phenomenon, which was noted in each of almost a hundred roots. In transitional zones, tripolar mitoses were very occasionally seen. In general, the effect of the higher concentration of colchicine is to produce a relatively higher proportion of c-mitoses, and of the volume occupied by them in the root. The plane of demarcation between the two zones does not remain stationary, but moves distally, reaching its peak, at which almost all division figures are c-mitotic, at about 11 hours of treatment.

Considering the occurrence of c-mitosis as the cytological indicator of the cell's susceptibility to colchicine, these results can be interpreted as a graded susceptibility, along the root's longitudinal axis, of the cells to colchicine. That differential permeability, or transport mechanisms, or intrinsic differences in the cell's physiology along the line of this gradient may be involved, is recognized but the data

do not yet permit any decision among the various alternative hypotheses.

A macroscopic result of the effects of colchicine is the induction of a bulbous swelling, or tumour, in the affected root-tip, the mechanism of the production of which is still controversial<sup>2,4,5</sup>. At these threshold concentrations, the continued mitotic, and cell-proliferatory activity of part of the meristem permits the formation of very elongate tumours, some one to two centimeters in length, over a period of days.

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2. William Hayden Memorial School, Columbia College.

3. Levan, Albert, Hereditas, 24, 471-486 (1938).

4. O'Hara, J.G., Jour. Hered., 30, 35-37 (1939).

5. Hawkes, J.G., Jour Genet., 44, 11-22 (1942).