The Cytonuclear Ratio in Relation to Changed Conditions of Lengthening in Young Roots

By *B. Cireli* and *Y. Vardar*
(Department of Botany, Ege University, Izmir, Turkey)

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In all classical books growth at the cell level has been defined as an irreversible increase of volume. Elongation signifies an increase along the long axis and enlargement an increase along the transverse axis of the cell. Both ways lead to cell growth and can be interpreted as results of the same metabolic mechanism. It has been shown a long time ago that inhibition of elongation of a plant cell or organ leads to an increased enlargement of this cell or organ. Growth changes of this kind have been observed after decapitation (Younis, 1954; Vardar and Tözün, 1958) and after treatment with colchicin (Geissler, 1950), coumarin (Burström, 1955) or illuminating gas (Hitchcock et al., 1923). The observations on the stimulation of growth in width and on differentiation in relation to the inhibition of growth in length lead one to think that the metabolic process causing increase of cell volume operates in two different directions and that, therefore, different reaction phases governing growth in both directions have to be considered.

There are many reports about a relationship between cell nucleotides and the phenomena of growth and differentiation (Porter, 1953; Potapow and Maroti, 1956; Clowes, 1956; Vardar and Tözün, 1958; Woodstock and Skoog, 1960; Vardar, 1962). Trombetta (1939), Thermann (1951) and Green (1962) indicated the presence of certain factors responsible for the changes in the cell-nucleus relationship concerning their growth and differentiation. Therefore, we tried to determine the changes of volume in the nucleus and in the cell. Parallel to this the longitudinal and transverse growth reactions of the same roots (kept under conditions of inhibition or stimulation of lengthening) were investigated. Young roots of *Vicia Faba* (12 mm long) and *Lens culinaris* (9 mm long) were used. Colchicin, coumarin, and coal gas of known concentrations and decapitation of roots were used as inhibitory agents. The principal results can be summarized as follows:

A typical inhibition in the longitudinal growth of the root as a whole and of its cortex and epidermis cells was seen after decapitation while growth in width and degree of specialization were accelerated in certain proportions (Fig. 1). Typical relative changes of size—shown by the longitudinal diameter R and the transverse diameter r—of the cells and of the nuclei were seen after decapitation leading to a total increase of size in both cells and nuclei (Fig. 2). During the same experimental period, an increase of 258% in elongation in undecapitated *Lens culinaris* roots and an increase of 83% only in decapitated ones was observed; while undecapitated roots did not show any enlargement an increase of 104% was observed in decapitated ones.

The results obtained with *Vicia Faba* were similar. Corresponding to an increase in elongation of 182% in undecapitated roots an increase of 30% was seen in decapitated ones; an increase of 98% in width occurred in decapitated roots corresponding to no increase at all in undecapitated ones.

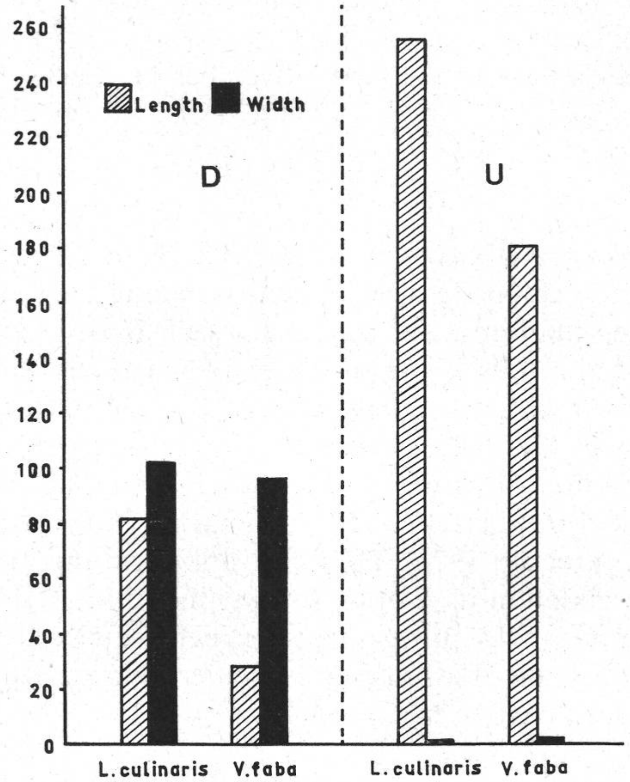

Figure 1

Length and width of decapitated (D) and undecapitated (U) roots of *Lens culinaris* and *Vicia Faba* at the end of the experiment

Obvious differences between decapitated and undecapitated roots were recorded for the total size of cortical and epidermal cells and their nuclei. If the average size of cortical *Lens culinaris* cells was taken as 100 at the beginning of the experiment it was found to be 1020% in the decapitated and 543% in the undecapitated roots at the end; the corresponding values for the size of the nucleus of the same cells were 246% in the decapitated and 111% in the undecapitated roots. Similar relations were obtained by the same calculations made for cortical cells of *Vicia Faba* root cells: the average cell size (size of nuclei in brackets) was 479% (225%) in decapitated and 234% (77%) in undecapitated roots.

Another interesting aspect of these experiments is the change of the R/r ratio. In general, this ratio is smaller than one in the cortical cells of the roots of both species at the beginning of the experiment; at the end of the experiment it is about 1 in decapitated roots and reaches 3 in undecapitated roots.

In general, the increase in size of the nucleus and of the cell is twice as high in decapitated roots as compared to undecapitated ones. In this connection the similarity between the specific growth of the nucleus and that of the nucleus of the endomitotic cells is important. Possibly the factors in nuclear activity, resulting from the mentioned situation of nuclear growth, are responsible for the inhibition of growth in length, for the stimulation of growth in width and for differentiation.

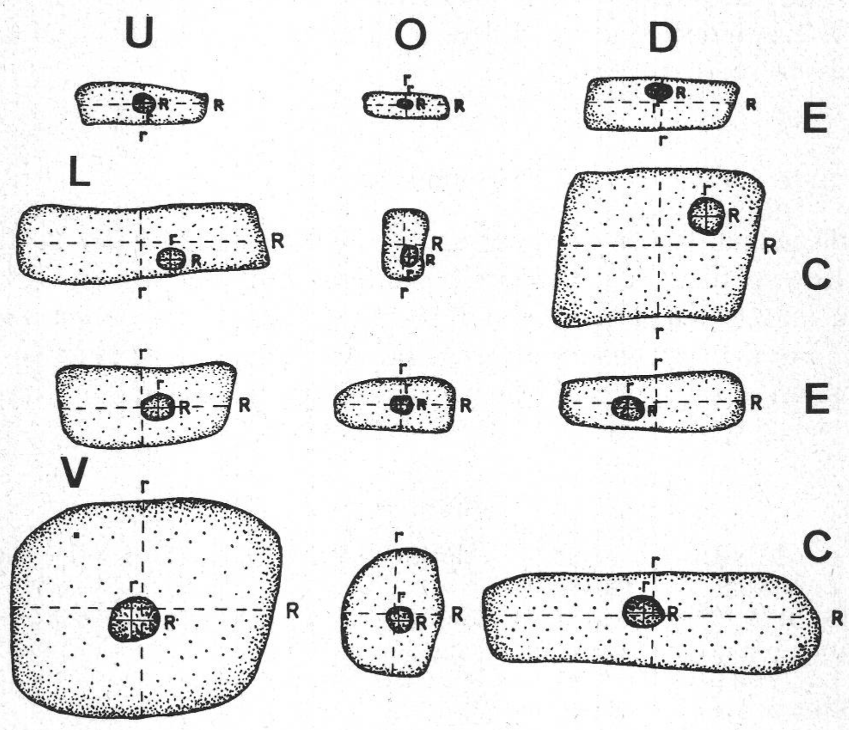

Figure 2

Epidermal (E) and cortical cells (C) of *Lens culinaris* (L, upper two rows) and *Vicia Faba* roots (V, lower two rows) at the beginning of the experiment (O) and at the end, decapitated (D) and without decapitation (U)

Similar results with almost the same relationship of effects were obtained with young roots treated with colchicin, coumarin, and illuminating gas. We also observed an increase in dry substance with decapitation. With decapitated *Lens culinaris* roots, an excess in dry substance of 101% over undecapitated roots under the same conditions was observed. Therefore, the increase in cell size is due not only to a change in water metabolism but also to an accelerated synthesis of dry matter. Baldovinos (1953) pointed out that cell enlargement and protein synthesis take place simultaneously. Staitz (1963) observed a rise in the total amino acid content in decapitated tobacco plants. An increase in the activities of various agents during lateral growth was also reported (Bult and van Raalte, 1961).

It is obvious from our results that the tendency of the volume to increase along the longitudinal axis changes, with decapitation, to a tendency of increasing along the lateral axis. This behaviour supports the possibility that decapitation changes the growth and shaping polarity of the cell. As a confirmation of this Green (1962) reported that colchicin changes the microfibril orientation, resulting in a differentiation of cell growth and shaping. Borgstrom (1939) indicated that this kind of change in polarity might occur in the cell due to factors such as ethylene, light, etc.

In addition to these observations a decrease in the intensity of respiration was found in decapitated roots. Generally, we can conclude that decapitation (or any other agent of similar action) puts the roots and their cells into a physiological state of more aged and advanced growth characterized by thickening and the appearance of root hairs. The interference of different metabolic events with cell differentiation as been discussed by Popham (1958).

Zusammenfassung

In der vorliegenden Arbeit wird der Einfluss der Entfernung der Wurzelspitze und anderer Faktoren (Cumarin, Colchicin, Leuchtgas) auf Längen- und Dickenwachstum von Wurzeln und Zellen und auf das Grössenverhältnis von Zellen und Zellkernen bei *Vicia Faba* und *Lens culinaris* untersucht. Alle genannten Faktoren hemmen das Längenwachstum und fördern das Dickenwachstum der Wurzel und ihrer Zellen.

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