

OCCURRENCE OF TRANSLOCATORY NUCLEAR MOVEMENTS IN THE VEGETATIVE CELLS OF ANGIOSPERMS ALONG WITH A DISCUSSION ON THEIR CAUSATION AND MORPHOGENETIC SIGNIFICANCE

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ABSTRACT

Occurrence of translocatory nuclear movements in the foot cells of filiform hooked hair of *Clitoria ternatea* L. and 2-armed hair of *Chrysanthemum indicum* L., during the ontogeny of these trichomes is demonstrated. The larger the cells, the more conspicuous is the nuclear movement observed. The movements are morphogenetically significant since they lead to cell divisions at a prescribed site, thereby contributing to development of the trichome conforming to its design. Nuclear movement being directional is interpreted to be a chemotropic response. The chemotropic factor is supposed to emanate from the site of prospective division and it is clearly indicated to be concerned with only the nuclear movement and not cell division. The events pertaining to the causation of nuclear movements and the consequences thereby are shown to occur in four major steps.

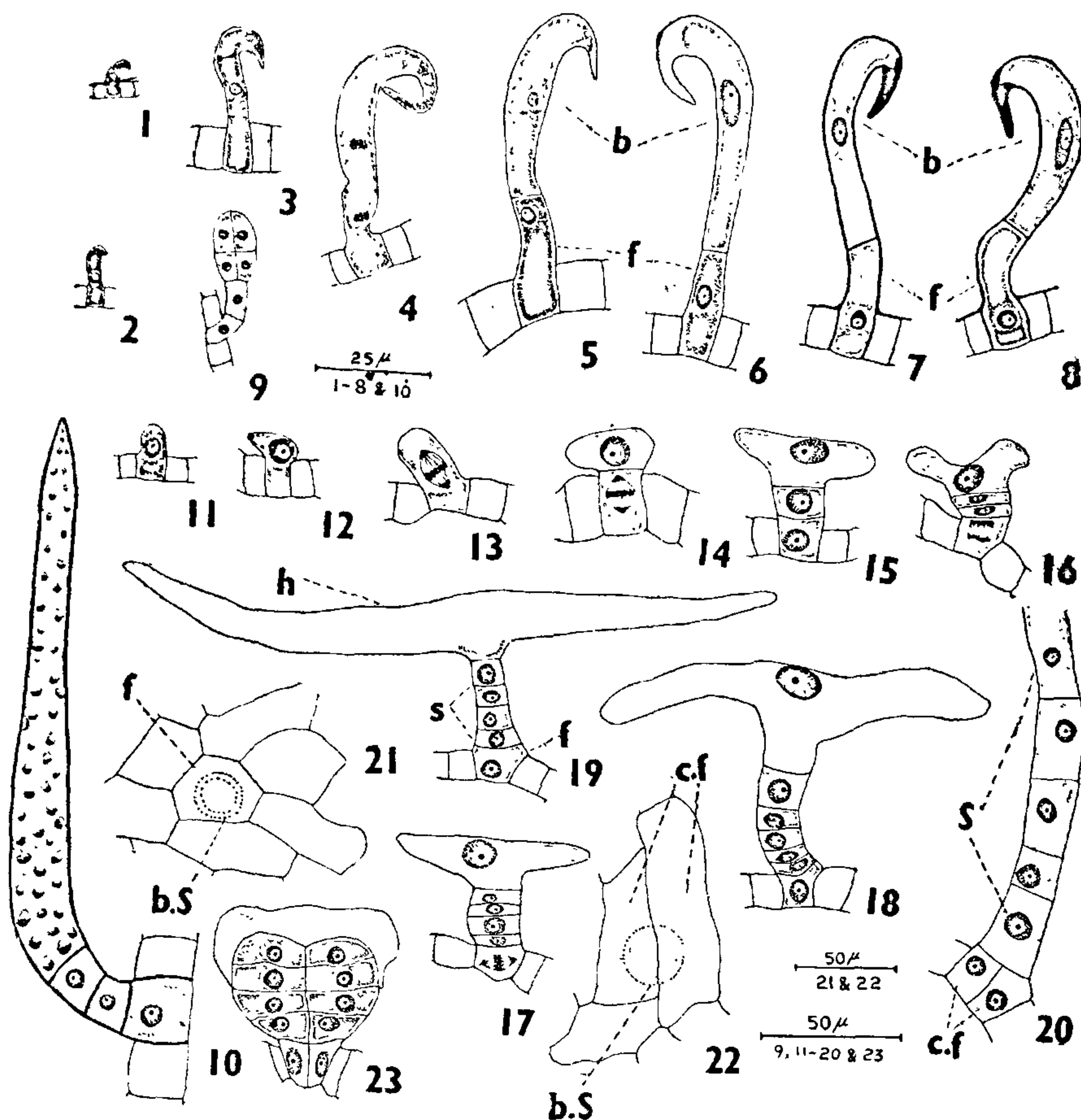
RECENTLY, Ramayya and Prabhakar⁷ presented evidence on the occurrence of autonomous intracellular translocatory nuclear movements during the development of unicellular stigmatic hairs in *Helianthus annuus*, and *Chrysanthemum carinatum* and of the unicellular filamentous hairs in *Lagascea mollis*. In the angiosperms although interphase nuclear movement of polar nuclei preceding the secondary nucleus formation is universal, the evidence presented by these authors is important in that it was concerned with vegetative nucleus and was based on calibration of specific parameters⁷. The findings are significant since, though much understanding has been gained regarding varied other intracellular movements of cellular components,^{3-9,10} there is little information concerning either the translocatory movements of interphase nucleus occurring in vegetative cells, or about their likely functional importance. In this paper, unlike with reference to unicellular trichomes, dealt with by Ramayya and Prabhakar⁷, evidence is presented on occurrence of interphase nuclear movements during the ontogeny of multicellular trichomes, the filiform hooked hair of *Clitoria ternatea* L. and 2-armed hair of *Chrysanthemum indicum* L. Further, comparing these movements with similar other situations an attempt is made to postulate on the likely factors involved in such movements and their morphogenetic significance during trichogenesis. Microtome slides prepared were stained with Ehrlich's haematoxylin², and the epidermal peels with aniline blue in lactophenol⁸.

Clitoria ternatea.—Filiform hooked hairs (Fig. 8) occur on the stem, leaf, calyx, corolla and ovary of the species besides two others, the macroform conical hair (Fig. 10) and capitate glandular hair

(Fig. 9). The filiform hooked hair, ontogeny of which is concerned here, is uniseriate, 2-celled, curved into a hook at the distal end, slightly thick-walled and stiff (Fig. 8). Its basal cell which represents the foot of the trichome, is peculiar in that it is conspicuously projected far above the epidermis, whereas the upper cell forms the body of the trichome (Fig. 8). The trichome develops from a single protoderm initial which is recognisable from those of the other associate trichomes due to its smaller size and the curved tip (Figs. 1, 2), a condition leading to the hooked form of the hair at its maturity. At this stage the nucleus lies at nearly the middle of the initial and nearly at the same level as the protoderm (Fig. 1), but soon as the initial starts elongating, the nucleus also moves upwards appearing far above the protoderm level (Fig. 3). Now, the initial undergoes a transverse division giving rise to two cells (Fig. 4), the lower of which matures into the foot, while the upper one into the body (Fig. 5). In the latter the nucleus gradually moves upwards, whereas in the former it starts moving downwards (Fig. 6). At maturity the nucleus in the body cell usually comes to lie just below the hook-bend, whereas in the foot-cell it comes back to the position from where it had moved in the initial stage of the trichome (Figs. 6-8). It may be noted that while the nucleus is still on move in either of the cells of the trichome, the walls become secondarily thickened (Figs. 7, 8), the movement of the nucleus thus least affecting the process of sclerification. It is apparent from the trichome ontogeny that the nucleus of the trichome initial makes a to and fro movement, in which the forward move is obviously directed by the site

of the prospective cell division, whereas the rear move is a blind one.

Chrysanthemum indicum.—This bears two trichome types, 2-armed hair (Fig. 19) and biserial vesicular



FIGS. 1-23. Figs. 1-10. *Clitoria ternatea* L. Figs. 1-8. Stages of development of filiform hooked hair. Figs. 1-6. From l.s. calyx (abaxial), Figs. 7 and 8. From l.s. bract (abaxial). Figs. 1-3. Show the nucleus moving upwards from trichome base before division. Fig. 4. Nucleus in division. Figs. 5-8. Nucleus making backward movement to the base of the foot cell after division. Figs. 9, 10. Capitate glandular and macroform conical hair respectively from a bract margin. Figs. 11-23. *Chrysanthemum indicum* L. Figs. 11-18. Stages of development of 2-armed hair. Figs. 11 and 12. Nucleus moving forwards before division. Fig. 13. First division of the nucleus. Figs. 14-16. Nucleus of the basal cell dividing to produce the stalk of the trichome. Fig. 17. Nucleus of the basal cell dividing anticleinally to give rise to compound foot after contributing derivative to stalk formation. Fig. 18. 2-armed hair showing the nucleus of head cell near the outer wall due to the movement of the nucleus from the base (compare with Figs. 14 and 15). Fig. 19. Mature 2-armed hair from l.s. leaf (abaxial). Fig. 21. Surface view of foot cell of 2-armed hair after breakage of the trichome at the base of its stalk (leaf abaxial). Figs. 20 and 22. Compound foot of 2-armed hair in l.s. and surface view respectively (from leaf abaxial). Fig. 23. Biserial vesicular glandular hair (from leaf abaxial). (Figs. 13, 15-19. taken from Ramayya, 1969). (b = body; b.s. = base of the trichome stalk; c.f. = compound foot; f = foot; h = head; s = stalk).

glandular hair (Fig. 23) of which the former, the ontogeny of which is concerned, here, is borne on leaf, stem, peduncle, phyllaries, corolla and ovary of the plant. The 2-armed hair is distinguishable into foot, stalk and head portions (Fig. 19). The foot may be unicellular or simple (Figs. 19, 21), or compound being usually 2- or 3-celled (Figs. 20, 22). The trichome develops from single protoderm initial (Figs. 11, 12) and as described in detail earlier by Ramayya⁶, a given initial usually divides thrice transversely giving rise to stalk and head (Figs. 13-17) subsequent to which it may as such mature into a simple foot (Figs. 18, 19, 21) or again divide anticlinally once or twice (Fig. 17) developing into a compound foot (Figs. 20, 22). What is, however, relevant here is that during the trichogenesis, in the trichome initial which acts as the basal cell of the developing trichome, the nucleus makes the same to and fro movements (as described in *Clitoria*), the forward move giving rise to daughter cells that contribute to the formation of stalk and head, whereas the rear, unlike in *Clitoria*, being not a blind one is usually followed by anticlinal divisions (Fig. 17) giving the compound foot. However, since the foot cell of the 2-armed hair is of a shorter length as compared to that in *Clitoria*, the to and fro distances traversed by the nucleus in the initial are not conspicuous. It is relevant that in the head cell of the 2-armed hair also, the nucleus makes to and fro movements (Figs. 15-18). Nuclear movements recorded above are also common in the development of numerous other multicellular trichome types as described by Ramayya⁸.

From the observations described it could be stated that the larger the cell, the more conspicuous is the nuclear movement as seen in the foot cell of the filiform hooked hair in *Clitoria* and the head cell in the 2-armed hair of *Chrysanthemum*, but it is negligible in smaller ones as in the stalk cells of the latter trichome (Figs. 18-20). Indeed nuclear translocation may not be necessary in smaller cells since no region in such cells would remain beyond serviceable distance from the nucleus regarding supplies of its essential products.

The findings, particularly those from the ontogeny of the 2-armed hair in *Chrysanthemum* are important in shedding light on the biological value of the nuclear movements. Since the forward move of the nucleus in the basal cell is followed by the cell division, it is clearly indicative of its importance in bringing about cell divisions that lead to formation of the stalk and head of the trichome towards its distal end. Similarly, the rear move of the nucleus is followed by cell divisions giving rise to the compound foot. In instances where the nucleus

on return does not divide as in some trichomes of the 2-armed hair of *Chrysanthemum* (Figs. 19, 21), or regularly in the filiform hooked hairs of *Clitoria* (Fig. 8), this shows that in these trichomes, though the nucleus is induced to move back, the capacity for cell division is lost. Thus the nuclear movements recorded suggest to be for the purpose of cell divisions at a prescribed site unlike those occurring during fertilization or secondary nucleus formation in embryo sac of angiosperms where they result in internuclear fusion. In the development of root hairs also, as they elongate, the nucleus maintains a corresponding forward movement¹¹, but this is said to help in maintaining their tip growth¹¹. In this instance, therefore, the nuclear movement helps in growth rather than leading to cell division. In some instances, however, nuclear movement is not suggestive of any specific morphogenetic or functional purpose. For example, this has been recorded in the case of the vegetative nucleus of pollen tubes and also synergid nuclei of some plants wherein they have been observed to simply wander in the upper end of the embryo sac⁵.

The present data are also significant in throwing light on some aspects of the causation of the intracellular nuclear movement. It is well known that directed movement of sperms towards eggs occurring during plant fertilization are considered to be chemotropic in nature⁴. Since the nuclear movements leading to cell division during development of the 2-armed hair and filiform hooked hair is directional and regulated in space and time, the authors regard this to be equally chemotropic, presuming the movement inducing stimulus to originate from the prospective site of cell division. In this context the blind rear movement of the nucleus observed in the basal cell of the filiform hooked hair is significant in as much as it provides some insight into the nature of the relationship between the nuclear movement and cell division. Normally these two phenomena occur together in close succession, the nuclear movement being followed by cell division as observed during the ontogeny of the two trichome types. But since in the basal cell of the filiform hooked hair the rear nuclear movement is not followed by cell division, it indicates that the movement inducing stimulus is distinct and separate from those causing cell division. Thus the cell divisions in the trichomes studied are indicated to be governed by several chemical stimuli at various levels acting in close co-ordination.

In retrospect the major events pertaining to the occurrence of intracellular nuclear movements observed in the trichomes studied can be resolved into the following: (1) origin of nuclear movement inducing stimulus, (2) movement of the

nucleus to the site of cell division, (3) organization of the cytoplasmic site to undergo division and (4) occurrence of cell division.

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INFLUENCE OF SCORPION VENOM ON ENZYME SYSTEMS OF SCORPION *HETEROMETRUS FULVIPES*

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ABSTRACT

Presence of cannibalistic behaviour amongst scorpions was observed. Addition of venom to the hepatopancreatic homogenate had no influence on the activity of succinate dehydrogenase while glutamate dehydrogenase was elevated. In the homogenate of cephalothoracic neuronal mass, the venom inhibited succinate dehydrogenase and increased glutamate dehydrogenase. These differential effects of venom are discussed.

INTRODUCTION

AN observation of cannibalistic behaviour in the scorpion, *Heterometrus fulvipes*, where one scorpion injects its venom and immobilizes the other, prompted us to study the effects of scorpion venom on the enzyme systems of scorpion tissues. Venom from different species of scorpions were shown to have six protein fractions³⁻⁶. Oommen and Kurup⁴ have suggested that the toxicity exists in the fractions having cathodic mobility and the relative toxicity of the venom depends on the proportions of the cathodic protein fractions⁷. Earlier investigations in our laboratory have shown that the administration of scorpion venom into cockroach inhibits respiration and decreases body temperature, succinate and lactate dehydrogenase, and acetylcholinesterase activity levels in the muscle and ventral nerve cord³. However, no reports are available on the effects of scorpion venom on its own tissues. Two enzymes were chosen as

representatives of oxidative and amino acid metabolisms.

MATERIALS AND METHODS

Scorpions were collected from local hilly terrain and were adapted to the laboratory conditions. They were kept in separate glass jars and were fed daily with cockroaches.

Venom was collected from freshly collected animals by applying electric shocks upto 15 V in the post-abdominal region with an Electronic Stimulator (Seemax, ST-5, Ambala). The venom was collected into a syringe and diluted with pH 7.4 (0.05 M) phosphate buffer. Protein level (2 mg/ml) was used as a check to obtain same dilution every time. Fresh venom was collected for each experiment.

Hepatopancreas and cephalothoracic nerve mass (referred as brain) were isolated from scorpions. Tissue homogenates were prepared in ice-cold 0.25 M sucrose solution in Potter-Elvehjem glass homogenizer. The homogenates were centrifuged

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