MICROSCOPIC STUDIES ON THE ORIGIN AND DEVELOPMENT OF THE HAIRS ON THE FOLIAR ORGAN OF *SYRINGA VULGARIS* L.[1]

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The ontogenetic approach has been proved helpful in the solution of problems in anatomy and morphology. Up to the present, however, it has been applied largely to the study of vegetative tissues and organs. A survey in the literature shows that the origin and the early stages in the development of buds as well as the foliar and floral organs or tissues of widely separated groups of plants have been investigated. Hair development, on the other hand, has received less attention. The work of Pearson (1948) seems noteworthy for his detailed accounts of the developmental history of the seed hair in *Asclepia syriaca.* Another paper (Garrison, 1949) has added to our knowledge on the ontogenesis of the axillary buds of *Syringa vulgaris,* a species which has been selected for the study relating to the ontogenesis of the hairs on the foliar organ. However, information concerning the development of the hairs has absolutely been neglected.

Plant hairs are often of physiological significance and sometimes they are also of taxonomic value. With incomplete and very meagre information on the ontogenesis of the hairs, it seems desirable that a comprehensive study and a brief description of the origin and development of the hairs be made. In this paper attention is centered upon the origin and the development of the general form of the hairs that appear on the leaf primordia in the buds and that exist on mature leaves of *Syringa vulgaris.*

Materials and Methods

Syringa vulgaris was selected as a species for this study. Both buds and a mature leaf were used in this investigation. A series of buds were obtained

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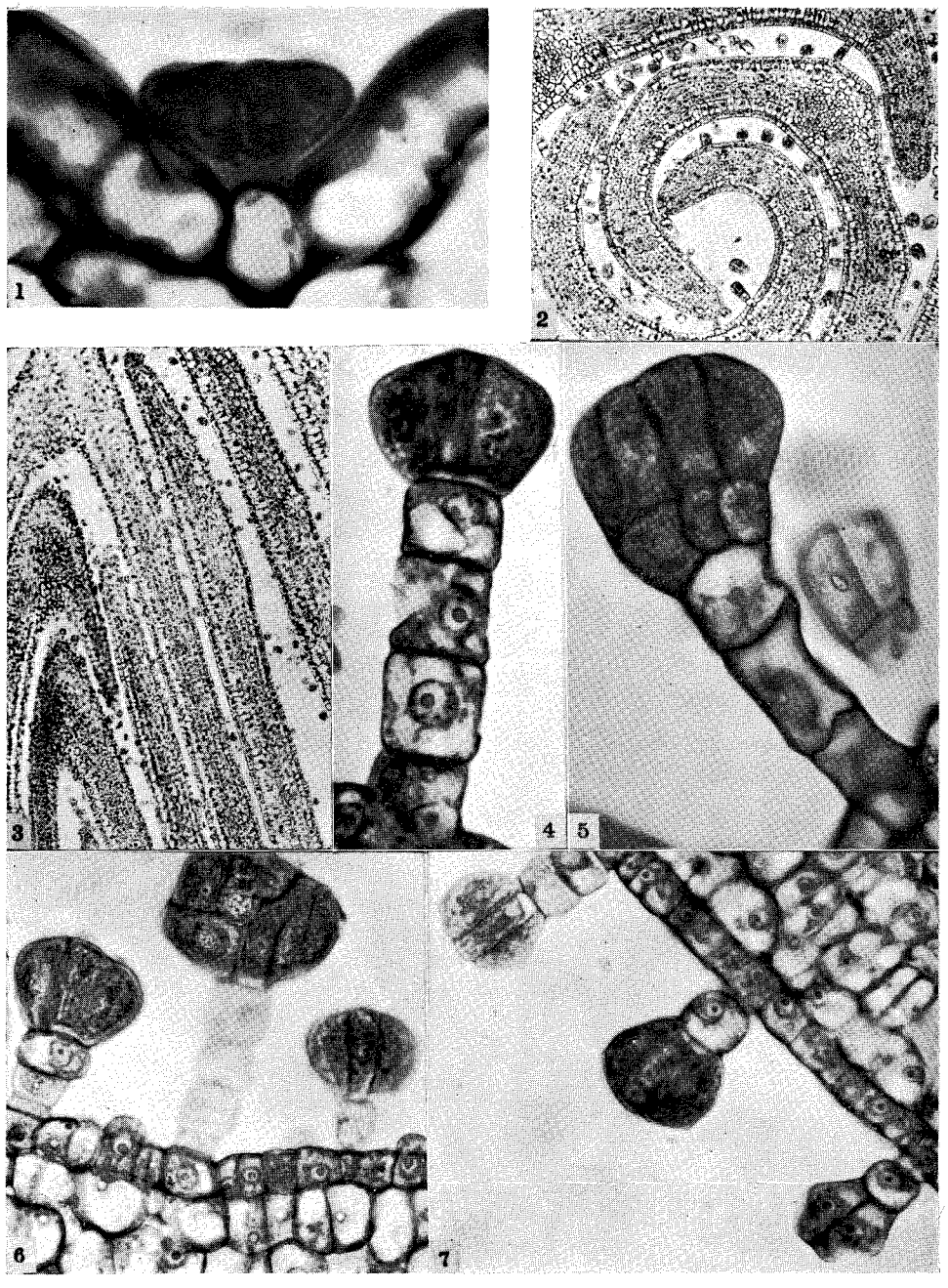
from Dr. Sedgwick. They were collected from the plant growing on the campus of Syracuse University, Syracuse, New York at some intervals during the period from April to July of 1957. Most of the buds were killed in CRAF III, dehydrated with ethyl alcohol and tertiary butyl alcohol solutions, and run into paraffin by the usual method (Sedgwick, 1957). Both cross and longitudinal sections were cut at 12 microns. The leaf was collected from the bush growing in front of the rear door of Lyman Hall on the campus of Syracuse University on October 23, 1957. The leaf was killed in CRAF III, dehydrated with ethyl alcohol and tertiary butyl alcohol solutions, imbedded in paraffin, sectioned, usually 12 microns thick, in transverse plane. Most sections were stained with fast green and safranin as well as Haidenhain's iron-alum haematoxylin and safranin stain. Some scctions were stained with safranin and anilin blue stain and others with George H. Conant's triarch quadruple and safranin stain (Sedgwick, 1957).

Observations and Discussions

The hairs in *Syringa vulgaris* may occur on petiole, sepal, and petal other than the blade of a leaf. However, they appear mostly on the blade and only very few hairs can be seen on the petiole or floral parts. They are formed from the epidermal tissue and are attached to a base originating by the division of epidermal cells (Plate II, Fig. 4). In fact, the epidermal hairs usually develop early in relation to the growth of the organ. Therefore the particular abundance of hairs on young developing foliar organ in bud is not uncommon. In most cases, the leaf primordia in the bud are densely covered with the hairs in question (Plate I, Fig. 2). Sometimes the occurrence of the hairs is so abundant and crowded that the spaces between leaf primordia seem to be filled up with the hairs. But it is evident that most of these hairs are ephemeral and only few of them may persist throughout the life of the foliar organ. Consequently, there are only a very small number of hairs that exist on the mature leaves

Plate I

Fig. 1. Transection of leaf showing regular hair on the lower surface of a mature leaf. ×952.
Fig. 2. Cross section of bud showing hairs on leaf primordia. ×80.
Fig. 3. Longitudinal section of bud showing hairs on leaf primordia. ×81.
Fig. 4. Cross section of bud showing a hair of maximum length. ×640.
Fig. 5. Cross section of bud showing a hair of maximum length with a head composed of two layers of cells. ×640.
Fig. 6. Cross section of bud showing hairs of different sizes and shapes at distinct developmental stages. ×448.
Fig. 7. Cross section of bud showing hairs with stalks of different number of cells. ×452.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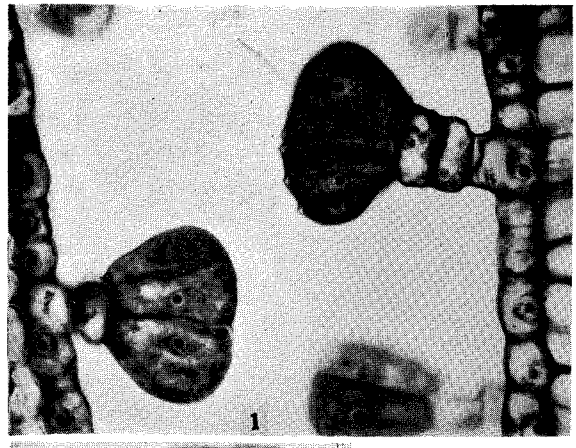

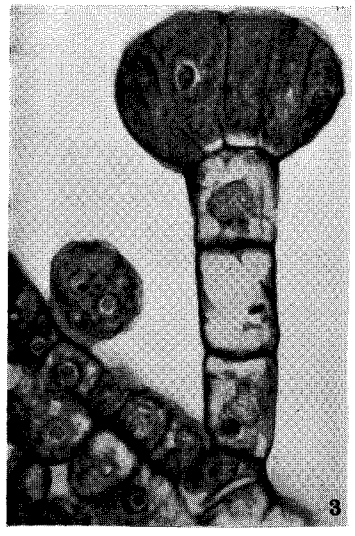

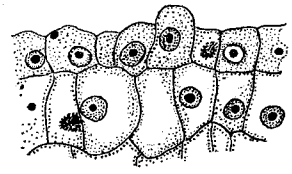
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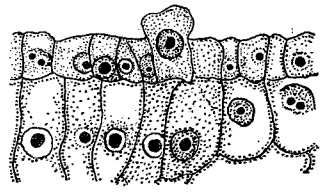
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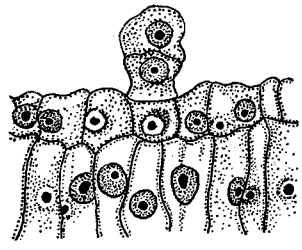

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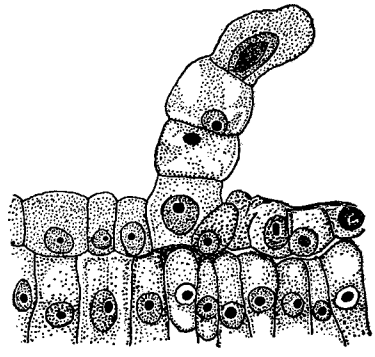
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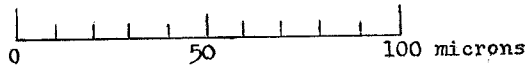

where they are always singly confined to the depressions formed on both surfaces of the blade (Plate I, Fig. 1), and hairs on the lower surface are usually more than that on the upper surface.

Hairs in *Syringa vulgaris* are generally of considerable uniformity although wide variations may be shown among hairs on the same surface of the leaf primordium in the bud or between hairs on the leaf primordia and that on the mature leaves (Plate I, Fig. 1 & 2). In general, the hairs are multicellular unbranched structures. Commonly a hair can be divided into a foot, which is imbedded in the epidermis, and a body projecting above the surface. The cells surrounding the foot are sometimes morphologically distinct from other epidermal cells. The body usually consists of a stalk and a head (Plate III). The stalk is a unicellular or multicellular part of a hair, being a cylindrical formation of a single row of one to four cells supporting the head which is a multicellular spherical structure made up of a number of cells. The stalks of the hairs on the young growing foliar organ in the bud are mostly made up of a few cells while those of the hairs on the mature leaves are commonly unicellular structures (Plate I, Fig. 1). The number of cells consisting of a head is from four to fifteen or more (Plate I, Fig. 4, 6, 7, & Plate II, Fig. 3). Structurally these cells are usually arranged in one layer of two to five rows; but sometimes they may be arranged in two layers (Plate I, Fig. 5), or the cells may occasionally be irregularly arranged (Plate I, Fig. 6).

The hairs are formed from epidermal tissue, being originated by division of epidermal cells (Plate II, Fig, 4, C). Some of the epidermal cells undergo differentiation, and each of these cells grows into a hair. Roughly speaking, a hair is initiated as a protuberance from an epidermal cell (Plate II, Fig. 4, A & B). The protuberance elongates and various divisions follow the initial elongation. At last it develops into a multicellular structure as a hair. The intervals between adjacent differentiated epidermal cells may be of a distance

Plate II

Fig. 1. Cross section of bud showing regular hairs of normal sizes and shapes. ×504.
Fig. 2. Cross section of bud showing adjacent hairs of diverse sizes and shapes at late developmental stage and the interval of two cells between them. ×632.
Fig. 3. Cross section of bud showing hairs of distinct sizes and shapes. ×640.
Fig. 4. Camera lucida drawing of cross sections of buds showing hairs at early developmental stages.
(A) The differentiation of the epidermal cell.
(B) Differentiating epidermal cell showing the migration, from the basal part to the upper portion of the cell, of the nucleus.
(C) A hair being originated by division of the epidermal cell.
(D) A hair showing the terminal cell from which a head will be developed full of cytoplasm.

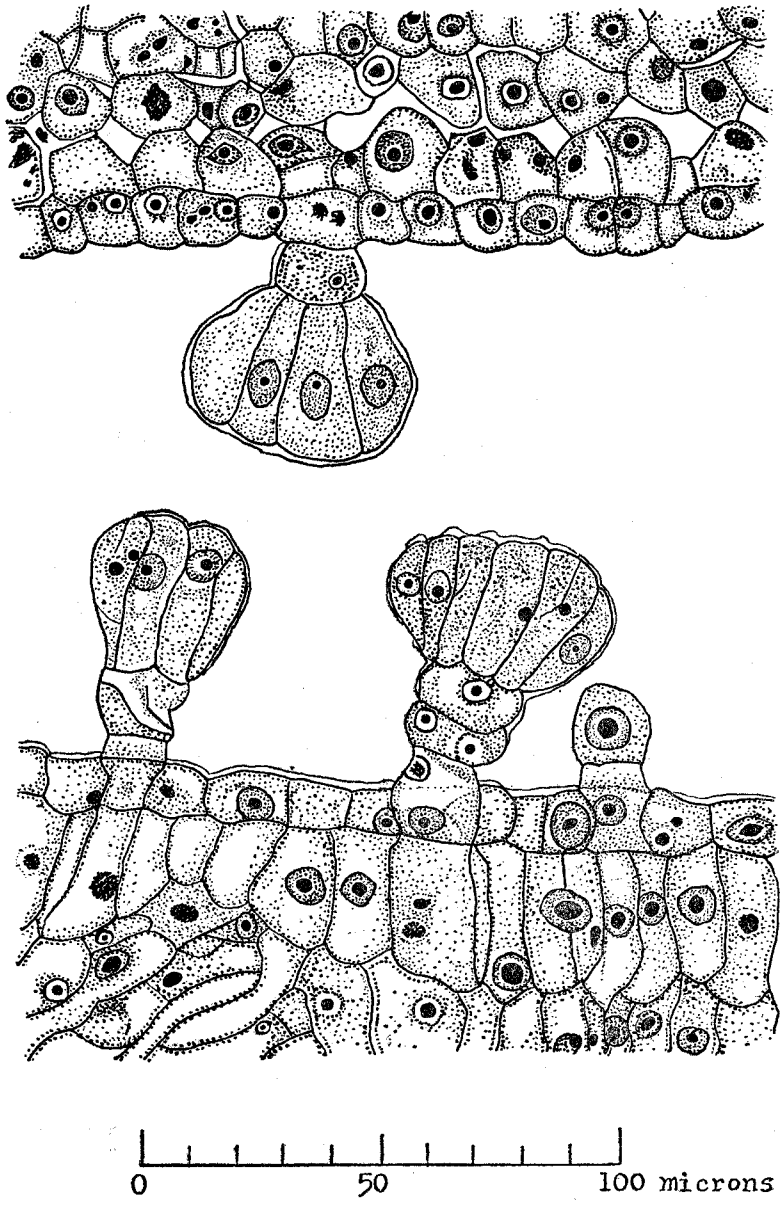

Plate III. Camera lucida drawing of cross section of bud showing regular mature hairs of normal size and shape, and a hair at early developmental stage.

from one to several cells or more (Plate I, Fig. 2, 6, Plate II, Fig. 2, & plate III).

Differentiation of hair-producing epidermal cells was first apparent in the bud at certain developmental stage and is characterized by an increase in the density of the cytoplasm (Plate I, Fig. 6). Therefore these cells become more and more distinct from their neighbours. Their cytoplasm becomes denser, their nuclei larger and their nucleoli very much larger. During this period there is an increase in the size of these cells. This is due to the enlargement of these cells already differentiated. It does not appear to have a definite age at which hair elongation is initiated for the buds of the developmental series, and it does not seem to be any very exact relationship between the time of the initiation of hair elongation and the stage of bud development. However, differentiation would not take place until the bud is completely developed because no hairs have been found in the bud collected in July. On the other hand, which or how many of the epidermal cells will grow or differentiate into hairs can not be anticipated unless evidence of differentiation can be seen or traced. It seems that the different hereditary and environmental factors of each of the epidermal cells may have some influence over the differentiation. Elongation is not initiated simultaneously by all the hair-producing epidermal cells; but it is going on progressively from time to time during the late developmental stage of the bud. Adjacent hairs may be of very distinct ages; one may be already at the age of maturity while the others nearby may be at the very beginning of differentiation or elongation (Plate I, Fig. 6, Plate II, Fig. 4, & Plate III). Consequently, hairs of different sizes, shapes, and structures at various differential stages usually appear in the same area on the developing leaf primordia in the bud (Plate I, Fig. 2 & 6).

Elongation of a hair-producing cell is accompanied by a migration of its nucleus to the upper portion of the protuberance (Plate II, Fig. 4, A, & B). The distance migrated is not entirely uniform for all the developing protuberances. In most cases, cells constituting the head of a hair are usually full of cytoplasm, while the cells of the stalk are mostly vacuolated (Plate I, Fig. 5, & Plate II, Fig. 3). The mature hairs are often surfaced with a cuticle. Hairs that are of maximum length and width are commonly confined to the primordia in the bud, but not on mature leaves.

The average maximum hair length was calculated for all buds of the developmental series, and the mean was based on the length of the longest hairs on the leaf primordia in the buds. However, the figure for hair length is merely an approximation though some of the longest hairs that could be located on the prepared slides were measured. According to the measurement, the maximum length of hairs ranges from 0.074 mm. to 0.123 mm, and the widest part of a hair is represented by its head. The maximum width is based on the diameter

of the largest heads. The heads of some of the hairs that could be located on the prepared slides were also measured. The diameter of the largest heads ranges from 0.047 mm. to 0.061 mm.. The ratio of length and width of a hair is always larger than one. In other words, the length of any hair is always longer than the diameter of its head. This is also true for the hairs on the mature leaves.

Summary and Conclusions

Hair growth of *Syringa vulgaris* is presented. A hair is initiated as a protuberance from an epidermal cell and elongates by means of divisions of the epidermal cells. Differentiation of all of the hair-producing epidermal cells does not take place simultaneously, but progressively from time to time during the developmental stages of the foliar organ in the bud. In fact, the hairs usually develop early in relation to the growth of the foliar organ.

The potentiality of differentiation which is probably determined by the hereditary and environmental factors of each of the epidermal cells can not be anticipated.

Most of the hairs are ephemeral and only a very small number of hairs can persist throughout the life of the foliar organ. Therefore the occurrence of a great number of hairs is naturally confined to the developing foliar organ or primordia in the bud. Relatively few hairs persisting on mature leaves are singly limited to the depressions formed on both surfaces of a leaf.

The hairs are multicellular unbranched structures and are generally of considerable uniformity although wide variations may appear among hairs occurring in the same area on the leaf primordia in the bud.

Structurally, a hair can be divided into three parts, a foot, a stalk, and a head. The maximum length of the hairs is about 0.1 mm. and the maximum width is around 0.055 mm.

丁香葉上毛茸的由來與生長之研究

王 忠 魁

植物體各種器官之表面往往有毛茸發生。毛茸之構成，形狀，與功能每隨植物之種類或器官之不同而異；因此可以採用爲鑑別植物種類之依據。此外毛茸之生成與存在對於植物生理而言亦有其意義。惜此等毛茸之發育經過情形尙待研究。

本文係就丁香成葉與不同發展時期之芽內葉原體上之毛茸從事顯微鏡下之觀察，俾窺其

本相，究其由來，進而得以充分瞭解此等毛茸之形態與解剖性質。所得結果約有下列諸端。

1. 毛茸係由少數表皮細胞先行橫向分裂再經縱向分裂發展而成。概多發生於幼芽時期。

2. 多數毛茸存在時期頗短，故此芽內葉原體之表面皆由各式各樣而發展時期不同之多數密生毛茸所覆蓋，而成葉上僅有極少數構成形態一致之毛茸着生。

3. 此等毛茸可以明顯的分爲頭，梗，及足等三部份；三者之構成形態與包括細胞之數量各不相同。(摘要)

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