GROWTH OF CORALLORHIZA MACULATA

THE growth of the unbranched scapes of the orchid, *Corallorhiza maculata* Raf., affords an opportunity to observe some phenomena not readily discernible in other plants. The scapes contain no chlorophyll and rise from fleshy, branched coral-like stems which are associated with mycorrhizal fungi, and produce a raceme which may bear as many as 40 flowers.[1] The materials out of which their tissues are formed are entirely derived from the short fleshy stems.

Plants transferred from their habitat under *Sequoia sempervirens* were established in large boxes of soil in the early spring. The initial growth of the scape consisted in the elongation of the embryonic cone with its sheathing scale. As soon as they rose above the level of the soil, measurements and records were started. The first evident development of scapes is the appearance of the enveloping scale above the mass of coralloid stems. Manual examination seems to show that the growing scape inside this scale kept pace with it for more than six weeks on a plant in the open air under natural conditions, where air temperatures ranged from 7° to 17° C., and soil temperatures from 8° to 13.5° C. The growth of the scale ceased shortly after the emergence of the scape.

The growth of the axis, registered on an auxograph which magnified 2.5 times, was negligible for the first week, followed by an acceleration with weekly increases of 4.4, 5.4, 6.0 and 5.6 mm. The tip of the scape was, however, sheathed in a second scale which grew at the same rate, but in time also allowed the tip of the scape to emerge. Between March 7 and April 1 a total height of 65 mm was produced, plus 5 mm after it opened. Its length was, therefore, 70 mm on April 2, measured from an ink-mark representing the level of the tip when the auxograph record was begun. On April 22 the third or uppermost scale had its tip 195 mm above the assumed base, representing an elongation of the internode plus scale of 125 mm since April 2. The elongation of the scale-scape axis suggested that they had a common basal meristem or at least two coordinated meristems.

The third scale emerged March 31 from the tip of its predecessor and it ceased growth on April 30. This third scale arose from a definite node on the scape and, like the second scale it contained no chlorophyll, grew for a short time, then dried out. This growth program was not dependent upon or influenced by light, being similar to that of another plant grown in complete darkness.

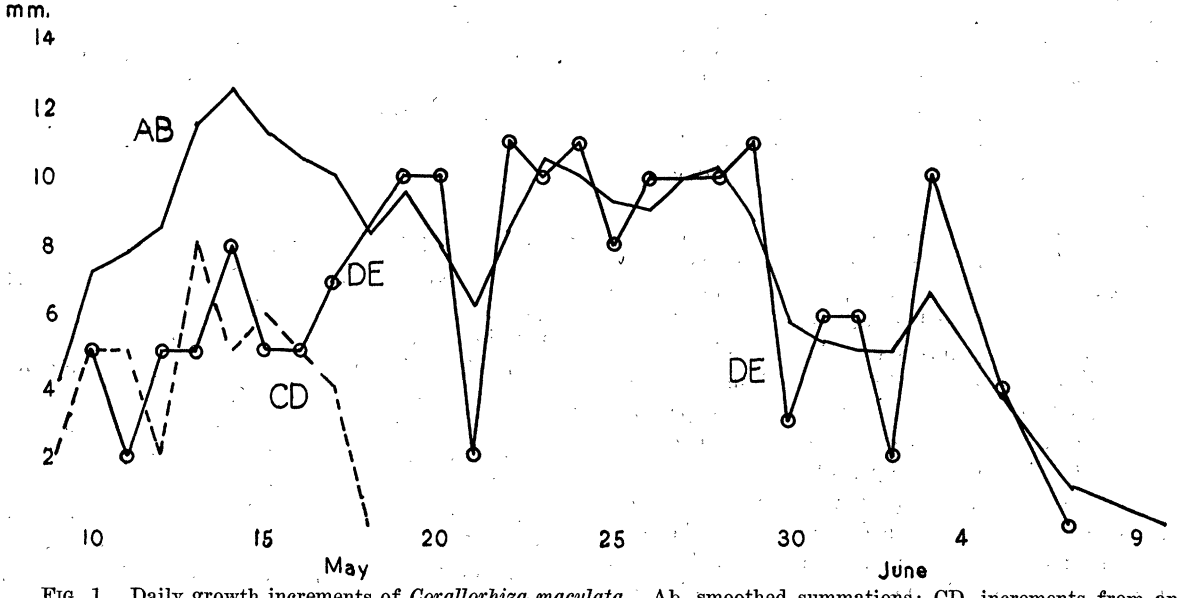

FIG. 1. Daily growth increments of *Corallorhiza maculata*. Ab, smoothed summations; CD, increments from an arbitrary mark near the base of the scape to the lowest pedicel in the inflorescence, showing that elongation of that region ceased May 18; DE, increments from the lowest pedicel to the tip of the inflorescence, showing the continued elongation of the upper region of the scape, and its relation to the part marked CD.

The zone of growth of scales was entirely basal. Derivatives of the meristem passed into a final form above the meristem in contrast to the process of final differentiation in the scape which occurred below (behind) the meristem.

The first phase of the active growth of Corallorhiza (Fig. 1, CD) reached a maximum on May 13 and

[1] MacDougal and Dufrenoy, *Plant Physiol.*, 19: 440–465, 1944.

ceased on May 18, indicating that the tissues below the inflorescence had then reached maturity. The second phase (DE) involving the growth of the inflorescence-bearing axis showed conspicuous irregularity of elongation at the start, but growth was fairly regular from May 19 to 29, then, with some irregularities, diminished and finally ceased June 11. The summation of the two phases (AB) shows that the growth of the entire scape had two maxima: the first of brief, the second of longer duration.

The term scape is here used to designate the flowering shoot of Corallorhiza, although features of growth and anatomical details not yet analyzed suggest that this member includes a reduced vegetative stem terminated by a raceme.

We are now in a position to emphasize certain unique features of the growth system of this plant.

The scape meristem at the base of the first internode is conjoined with that of the first sheathing scale. Its cell division and extension constitute the elongation of the first stages of the scape. Our measurements show that growth during this time is dependent upon growth-promoting substances contained in the basal region. Growth proceeded at a remarkably uniform rate, implying that materials were flowing upward from the base without accretion from the newly-formed cells. The meristematic cells passed into cell layers which in mature form lost their original character, but simultaneously those above that zone took on the meristematic character and produced new cell tracts.

The basal cells of the scape below the meristem passed into a mature condition, but the meristem was progressively pushed upward, carrying ahead of it the terminal portion, which was then in an embryonic condition. During this stage, the internode bearing the third scale was being differentiated above it. The coordinated growth of the node and the scape above it duplicated the growth of the basal internode with the result that the intact apex of the third scale was pushed up through the tip of the second, from which it and the node soon emerged completely. The scape then included an elongating basal internode a few centimeters in length and a similar meristem in a younger stage in the internode above. The salient feature of this activity of two coordinated meristems is shown by the graphs of Fig. 1.

A unique system of translocation of material then prevailed. Carbohydrates and other building materials synthesized in the underground organs were hydrolyzed and moved upward to the meristem and through it to the meristem of the upper internode and then into the embryonic inflorescence. This movement was not, as ordinarily, through vessels, sieve-cells or other conduits, the only xylem element recognized being a few spiral vessels. This feature of solute translocation through an active meristem is unknown in any other plant in so far as the present writers are informed. No effective agency can be predicated. The rate of conduction is so adequate that surplus starch is accumulated through the length of the scape, not excluding the meristematic region.

In the next stage the inflorescence is pushed from the tip of the uppermost scale and is followed by the development of flowers and seed-pods, thus creating a still greater draft on the translocated material. Particular attention was devoted to the influence of the flowers on the rate of elongation of the main axis. The two lower flower-buds diverged from the axis on April 28 concomitant with swelling of the buds. It was noted with great interest that flowers opened only after the region of the axis from which they arose had ceased elongation.

A remarkable feature is the translocation of substances necessary for growth through an active meristem; indeed, during a short period they passed through two meristems. Growth under natural conditions in the open air lacked the salient features of the S-shaped curve characteristic of other plants, as the high rate of acceleration, shown by the summation graph, was in the early stage of development.

D. T. MACDOUGAL

CARMEL, CALIFORNIA

H. S. REED

UNIVERSITY OF CALIFORNIA,
BERKELEY

GUANIDINO ARSENICALS

FOLLOWING up the recent work from these laboratories on amidino arsenicals,[1] the study of the guanidino arsenicals has been undertaken, since our search of the literature has failed to reveal any compounds of this type, and certain of the closely related ureido arsenicals, like carbarsone (*p*-ureidobenzenearsonic acid), possess useful therapeutic properties.

Of the various methods[2] which have been employed for the synthesis of guanidine derivatives related to the kind we have in mind, one of the simplest is that utilized by Ville[3] for the preparation of N-guanylsulfanilic acid (I) by condensing sulfanilic acid with cyanamide.

$H_2NC(:NH)NHC_6H_4SO_2OH$ (I)
$H_2NC(:NH)NHC_6H_4AsO(OH)_2$ (II)
$H_2NCONHC_6H_4AsO(OH)_2$ (III)
$H_2NC(:NH)NHC_6H_4As:AsC_6H_4NHC(:NH)NH_2$ (IV)

A similar condensation therefore was attempted between cyanamide and arsanilic acid, and the ana-

[1] Linsker and Bogert, *Jour. Am. Chem. Soc.* (a) 65: 932–935, 1943; (b) 66: 191, 1944.
[2] Bischoff, *Jour. Biol. Chem.*, 80: 345, 1928.
[3] Ville, *Comp. rend.*, 104: 1281, 1887; *Bull. soc. chim.* [2], 49: 41, 1888.