coleoptiles of *Avena*[8] and *Zea*[9,10]; epicotyls of *Phaseolus*[11]; hypocotyls of *Helianthus*[12] and stems of *Coleus*[13].

It is not clear from our results how this differential distribution of auxins in horizontal poplar stems arises, but by analogy with the results demonstrated for coleoptiles it would seem that there is a lateral movement of auxin from the upper to the lower side. The lesser activity of the cambium of the lower side may be explicable in terms of the greater content of growth inhibitory substances to be found there.

Our results with *Populus* are also in agreement with the recent work of Cronshaw and Morey[14] and of Kennedy and Farrar[15]. These workers applied tri-iodobenzoic acid (which is known to antagonize the effects of endogenous auxin) to vertical poplar stems and induced the formation of tension wood. This tissue normally occurs on the upper side of inclined branches and would thus seem to be indicative of reduced concentrations of auxin.

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[1] Wareing, P. F., and Nasr, T. A., *Ann. Bot.*, **25**, 321 (1961).
[2] Wareing, P. F., Hanney, C. E. A., and Digby, J., in *Formation of Wood in Forest Trees* (edit. by Zimmerman, M.) (Academic Press, New York, 1964).
[3] Bennet-Clark, T. A., and Kefford, N. P., *Nature*, **171**, 645 (1953).
[4] Frankland, B., and Wareing, P. F., *Nature*, **185**, 255 (1964).
[5] Nemec, B., *Jb. Wiss. Bot.*, **36**, 80 (1900).
[6] Haberlandt, G., *Ber. dtsch. Bot. Ges.*, **18**, 26 (1900).
[7] Audus, L. H., *Symp. Soc. Exp. Biol.*, XVI (1962).
[8] Dolk, H. E., English translation of *Rec. Trav. Botan. Neerl.*, **33**, 509 (1936).
[9] Gillespie, B., and Thimann, K. V., *Plant Physiol.*, **38**, 214 (1963).
[10] Goldsmith, M. H., and Wilkins, M. B., *Plant Physiol.*, **39**, 151 (1964).
[11] Boyson-Jensen, P., *Kgl. Danske Videnskab. Selskab Biol. Meddelesar*, **13**, 1 (1936).
[12] Brauner, L., and Blöck, A., *Planta*, **60**, 109 (1963).
[13] Lyon, C. J., *Plant Physiol.*, **40**, 18 (1965).
[14] Cronshaw, J., and Morey, P. R., *Nature*, **205**, 816 (1965).
[15] Kennedy, R. W., and Farrar, J. L., *Nature*, **208**, 506 (1965).

## Retardation of Flower Opening in *Oenothera lamarckiana* caused by Blue and Green Light

IF a plant of *Oenothera lamarckiana* Ser. is placed in a dark room 1 h before the flowers would have opened outdoors, all the flower buds open within 1 h because they have reached the physiological stage of development which permits them to bloom on the same evening. On the other hand, if the plant is exposed to continuous illumination with white light of sufficient energy there is no flowering as long as the plant is exposed to the light. These phenomena show that light retards the opening of the fully developed flower bud of this plant, and that the opening of the flower of *O. lamarckiana* has a response to light and dark which is different from the response shown by *O. berteriana* and several other species of *Oenothera*[1-3]. In addition, it was shown that the light sensitive region is located in the flower bud.

The buds used for the experiments were produced on plants of *O. lamarckiana* grown outdoors in pots. Plants with buds were placed in a dark room about 1 h before the expected time of natural flower opening and the buds were exposed unilaterally to monochromatic light. The illumination with monochromatic light of various wavelengths between 412 and 550 mμ was adjusted uniformly to an intensity of about 600 erg/cm²/sec at the sensitive part of the bud, and of more than 600 erg/cm²/sec in the case of wavelengths shorter than 395 mμ or longer than 570 mμ. Monochromatic light was obtained by passing light from a tungsten bulb through a coloured glass filter and a metal interference filter. Thirty combinations of glass and metal interference filters with $T_{max}$ ranging

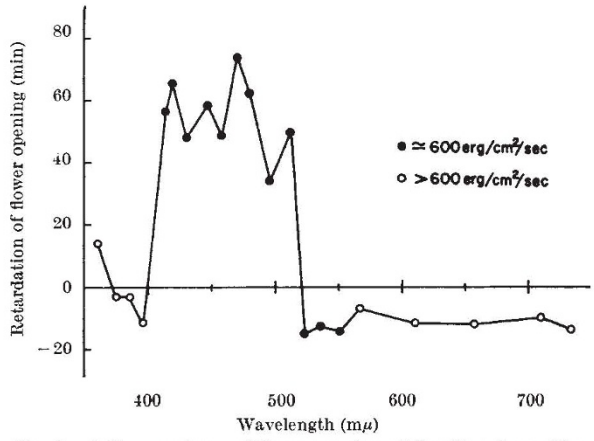


Fig. 1. Action spectrum of flower opening of *Oenothera lamarckiana*.

from 34 per cent to 52 per cent, at $\Delta\lambda 1/2$ 10–14 mμ, were used to obtain the different narrow spectral regions. Because the time of flower opening was affected by the outdoor light conditions on the day of the experiment, the retarding effects of each monochromatic light have been expressed in terms of the length of time which elapsed between the full opening of the buds on plants kept outdoors and of those on the illuminated plants. The temperature during the experiment was $23{\cdot}0 \pm 1{\cdot}0°$ C, and the relative humidity $67 \pm 5$ per cent.

In the action spectrum for the retardation of flower opening shown in Fig. 1 each point is the mean of the significant values chosen according to a modification of Haldane's method. This action spectrum clearly shows that the spectral regions around 362, 419, 447, 473 and 512 mμ have a retarding effect on flower opening. The action spectrum at wavelengths shorter than 500 mμ has similar peaks as that in the low energy range for the positive phototropism in the *Avena* coleoptile[4] and the *Phycomyces* sporangiophore[5]. The induction of retardation of flower opening by light around 512 mμ is interesting because it proves that green light has a physiological effect on higher plants.

These results are in agreement with those obtained in a series of preliminary experiments on flower opening of *O. lamarckiana* in which monochromatic light was obtained by passing solar light through the same series of filters as in the above experiment.

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[1] Arnold, C. G., *Planta*, **53**, 198 (1959).
[2] Sigmond, H., *Beih. Bot. Zbl.*, **46**, 479 (1930).
[3] Sigmond, H., *Beih. Bot. Zbl.*, **47**, 69 (1931).
[4] Thimann, K. V., and Curry, G. M., *Light and Life* (edit. by McElroy, W. D., and Glass, B.), 646 (Johns Hopkins Press, 1961).
[5] Curry, G. M., and Gruen, H. E., *Proc. U.S. Nat. Acad. Sci.*, **45**, 797 (1959).

## Flower Induction in Excised Shoot Apices of *Pharbitis* and *Chrysanthemum* cultured *in vitro*

THE existence of flower-inducing substances has been demonstrated by many workers, although it has been done in a more or less indirect way. Efforts to extract and isolate these substances, however, have so far had but few encouraging results. One of the main reasons for the rather disappointing results could be attributed to the lack of a proper means of detecting the active substances.