

## THE EFFECT OF TEMPERATURE ON FLOWERS

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(WITH ONE FIGURE)

This paper is concerned with the opening and closing processes in the flowers of *Crocus* and *Tulipa*. As is well known from the work of PFEFFER, the flowers of *Crocus* and *Tulipa* are only slightly photonastic. They are, however, extremely thermonastic. As regards this thermonastic response *Crocus* is much more sensitive than *Tulipa*. In the case of *Crocus*, the temperature may be so low that the flowers cannot open, yet the flowers may develop fully, nevertheless. Thus PFEFFER found that in temperatures below 8° C. the flowers developed but did not open. He found that the flowers of some *Crocus* plants opened to an extent with fluctuations of only 0.5° C. He made this thermonastic movement more evident by means of a fine silver wire which projected beyond the flower division and which was fastened to the latter by means of lacquer. Others have found that a very fine glass capillary will serve this purpose equally well.

My experiments show that the flowers of one species of *Crocus* are capable of responding to a somewhat smaller temperature change than 0.5° C. This is the case with the flowers of *Crocus vernus* which has been found to be the most sensitive to temperature changes of any of the species of *Crocus* thus far investigated. To test this point a study of eight species of *Crocus* has been made. The "constant temperature room" has rendered excellent and trustworthy service, but it is not so easily nor so closely controlled as the device here described which has been constructed for this study. (See fig. 1.) This apparatus consisted of a bell-jar, A, of wide but low form, with an opening at the upper end for the insertion of a very sensitive thermometer, B, wires for the electric current, C, and a suitable stopper, D, for adjusting and holding these in place. A pair of bell-jars similar to the one just mentioned, the outer being somewhat larger than the other so as to cover the inner one, and held in place by a wire adjustment is even better under certain conditions. Or, an ordinary double-walled bell-jar serves the purpose very well where special precautions are necessary. In this case, however, provision must be made for the entrance of the electric wires under the base of the jar. In the low form of bell-jar shown in fig. 1, the electric wires encircle the interior at the bottom and are held in place by means of perforated perpendicular glass rods or posts, E. These glass supports are of such length as to allow several coils of number 20 nichrome heating wire, F, to be used. It was necessary to determine exactly before beginning the experiment what adjustments were required to raise and

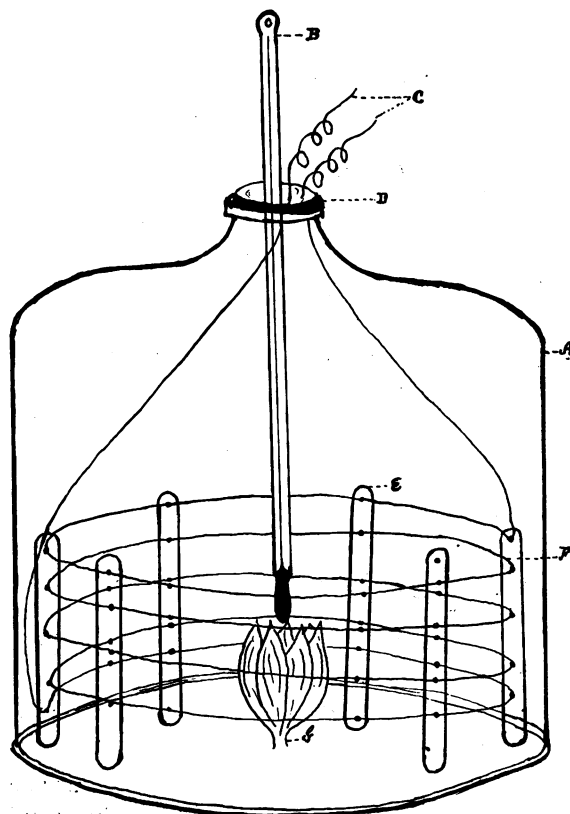


FIG. 1. Apparatus for demonstrating thermonastic responses of flowers.

maintain the temperature of the bell-jar to the desired point. With this apparatus the necessary heat for causing the opening movements of the flower segments of *Crocus* and *Tulipa* was readily produced by electricity. When the current was passed through the coils of nichrome wire, fig. 1, the necessary temperature was slowly or quickly produced according to the adjustment made. This was accomplished very exactly by using an electric current of 110 volts which was controlled by a lamp resistance in series with an adjustable wire rheostat. This arrangement also allowed the experiments to be performed either on potted plants, or better, on plants grown in the open and at any desired distance from the source of the current by increasing the length of the conducting wire. In this way the apparatus could be quickly placed over plants growing in flower beds. When it was observed that the flowers were in a probable condition for opening, the bell-jar, arranged as shown in figure 1, could often be placed over a considerable number of buds or flowers of *Crocus*. If the buds and flow-

ers of *Crocus*, G, are in an active condition, they can be caused to open or close respectively 12 times in immediate succession by alternately warming, or cooling to an appropriate degree, suitable buds or flowers on cool days. In order to cover a considerable number of buds or flowers by the bell-jar, consideration should be given previously to the planting of *Crocus* for such experimentation. This plant will bear rather close setting of its corms without detriment.

For the study of the opening and closing processes in *Tulipa* much taller bell-jars than the one shown in fig. 1 must be used, and the wire arrangement for heating increased and placed on the interior of the bell-jar in accordance with the height of the flowers. Although, as stated, *Crocus* is only feebly photonastic, still some objection has been offered to certain experimentation carried out with potted plants of *Crocus* in a room. The apparatus here described, effectively removes this objection, since it brings to bear on the plants enclosed by the bell-jar only the temperature effect, and leaves the influence of light out of doors unaffected. The other *Crocus* plants in the experimental plot therefore, serve in this connection as controls. This apparatus when used on *Crocus* and *Tulipa* in the open has also the additional advantage that the plants are under somewhat more natural conditions in other respects than is the case with potted ones. By the use of this apparatus ROYER'S idea that transpiration effects the flower movements is disproved, since this condition by my apparatus is controlled. These experiments are best carried out on cool days since then all the flowers out of doors are closed, while those that are in a responsive state under the electrically warmed bell-jar, can be caused to open. Caution should at all times be observed, to select flowers which have attained the proper stage of development. This is sometimes difficult to determine, or can be ascertained only by their failure to respond to the temperature changes. The flowers may be too immature, but more often they are too old and hence have passed, with respect to temperature, their perceptive condition. After a *Crocus* or *Tulipa* bud has been opened by warming under the bell-jar, then by removing the bell-jar or otherwise filling it with cool air, the open flowers will close. This occurs more quickly in *Crocus* than in *Tulipa*. The opening and closing of the flowers in both *Crocus* and *Tulipa* also take place rapidly or slowly according to the changes in temperature, within their responsive ranges. A slight fullness of the *Crocus* bud indicates a condition for opening, although this may be deceptive. Single flowers may be made to open very rapidly, if placed, as PFEFFER points out, in warm water after removal from a cool place. These flowers, however, rarely stand upright in the water, which makes some observations of their behavior less obvious. This difficulty may be overcome by enclosing the lower end of the perianth tube in a rather closely fitting glass tube of proper weight and

length, so that part of the glass tube's weight and lower end rests lightly on the bottom of a wide crystallizing dish in which the warm water is only a few cm. in depth. By this method a good many flowers may be observed simultaneously and the extreme opening process may be followed to good advantage.

By means of the electrically warmed bell-jar described here, flowers of *Crocus vernus* experimented upon out of doors were caused in many instances to open to an extent by increasing the temperature by only 0.2° C. The flowers of *Tulipa*, as is well known, are less responsive and no flowers of this plant were found that showed any tendency to open with a change of less than 1° C. In both of these plants the response that did occur in the flowers was much slower than when the temperature was higher or more favorable in the warmed air of the bell-jar or in the warm water. These experiments show that the flowers of both *Tulipa* and *Crocus* are much more sensitive to temperature changes than has been observed heretofore for these plants.

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