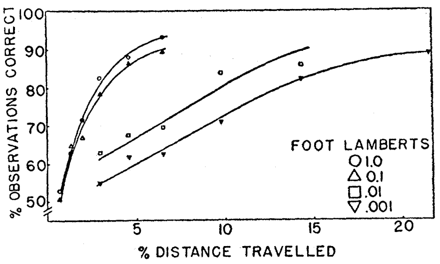

Fig. 1. Accuracy of detecting movement in depth as a function of the observed distance traveled for four luminance levels. The 50-percent value on the ordinate represents chance performance. The curves are the average for binocular and moncular conditions. Each point is based on 400 observations.

with a chin rest adjusted so that he could view the stimulus object through an aperture in the front of the booth. This arrangement provided direct visibility of the stimulus object in an otherwise totally stimulus-free visual field. The subject was alerted a few seconds prior to each trial presentation. The stimulus object then appeared for a controlled duration. The subject responded with a two-way throw switch to indicate whether the object appeared to approach or recede. Subjects were not informed of the correctness of their responses. A two-category, forced-choice method was used—that is, the subject had to respond with his best guess. The order of presentation (whether the object approached or receded) was selected from a table of random numbers, but was controlled so that each condition appeared an equal number of times.

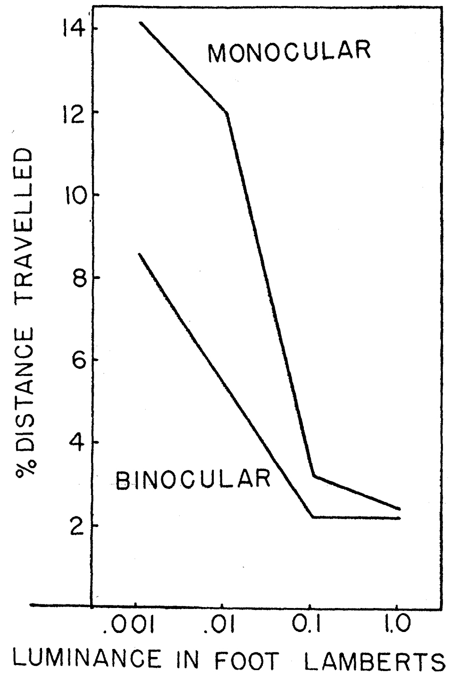

Fig. 2. The percentage distance traveled required for 75-percent correct detection of movement in depth as a function of luminance level for monocular and binocular viewing conditions.

Some of the results showing the percentage of correct observations as a function of the percentage of the original distance traveled for the four luminance levels used in the study are presented in Fig. 1. The percentage distance traveled is directly proportional to observation duration and, for the range of values involved, it approximates percentage change in visual angle subtense of the stimulus object. The curves shown are the average curves for both binocular and monocular vision. The 50-percent value on the ordinate represents chance performance, since with no information the subject, by guessing, would be correct about 50 percent of the time.

The data shown are for the average of the measures for conditions when the stimulus approached and receded. Although each condition occurred an equal number of times, on 51.9 percent of the observations the subjects reported that the object was approaching. This small, though statistically significant bias, may indicate that when the object approached, the movement in depth was more easily perceived than when it receded for any given observation duration. This would be expected because a slightly greater visual angle change occurs per unit time when the object is approaching than when it is receding. Also, there may have been a response preference independent of the stimulus conditions which would account for this small bias.

Figure 2 presents the percentage distance traveled required for 75-percent correct detection of movement in depth as a function of luminance for monocular and binocular viewing conditions. The percentage distance traveled required for 75-percent correct detection decreases with increasing luminance up to 0.1 ft-lam. The further luminance increase to 1.0 ft-lam does not affect binocular performance and only slightly lowers thresholds for monocular performance. This finding is in general agreement with studies of other visual functions as they relate to luminance (*1*).

The marked superiority of the binocular over the monocular viewing condition for the lower luminances is not easily accounted for. Since no other stimuli were in the visual field, disparity cues were not present and convergence cues could contribute very little, if any, information for the viewing distances involved. The only reasonable cue available for discriminating the movement in depth was the change in retinal image size in time. Conceivably, binocular summation of the stimulus energy could account for at least part of the superiority of the binocular condition at the lower luminance levels (*2*). Smith (*3*) found a definite superiority for binocular over monocular viewing in a similar visual task. However, Smith used luminance levels in the order of the higher levels used in the present study, and at these luminance levels binocular summation of energy should contribute little, if any, improvement. An analysis of the superiority of binocular over monocular visual acuity has been reported elsewhere (*4*).

No improvement in performance was evident with the practice afforded during the course of the experiment. The intersubject variability in the performance of this task was considerable at the lower two luminances, but was small for the higher two luminances.

Charles A. Baker
William C. Steedman
Behavioral Sciences Laboratory, Wright Air Development Division, Wright-Patterson Air Force Base, Ohio

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23 February 1961

Auxin Gibberellic Acid Interaction in Controlling the Hypocotyl Growth in Seedlings

Abstract. High concentrations of indole-3-butyric acid, when applied at a concentration of 100 to 200 parts per million (ppm) to presoaked seeds, cause a marked inhibition of hypocotyl length in the seedling growth of *Phaseolus mungo* var. T-2. Gibberellic acid, when applied at a concentration of 5 ppm, quantitatively reversed this inhibition. It is suggested that the interaction between these two growth substances controls the morphogenetic differentiation in regard to hypocotyl formation in seedling growth.

Interactions of growth substances are known to regulate the morphogenetic changes as the production of roots or buds in the tobacco pith callus tissue (*1*) and the growth of the preformed buds in the pea stem sections (*2*). Kuse (*3*) showed that both auxin and gibberellin were required for the growth of the petiole in the leaves of *Ipomea batatus* Cv. Norin No. 1, and Skinner *et al.* (*4*) brought forward evidence that interactions between gibberellins and substituted purines indeed control seed germination. The phenomenon of the different mode of seedling growth in different genera of the same plant

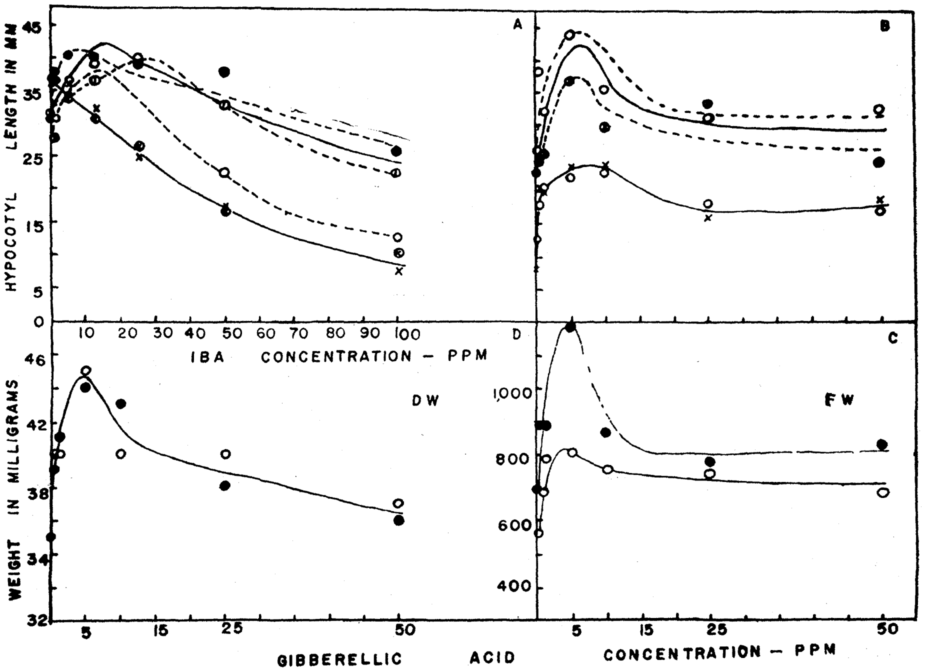

Fig. 1. Changes in the hypocotyl length at different growth periods as affected by different concentrations of indole-3-butyric acid (IBA) treatment (*A*), the reversal of inhibition in length caused by gibberellic acid with a concentration of 100 ppm of IBA (*B*), fresh weight changes (*C*), and dry weight changes (*D*). Curves marked with a single × and a circled ×, 3 days in two experiments; open circles, 4 days; circle with vertical line, 7 days; solid circles, 8 days. In *B*, the circled × has been used for 7 days.

family has not yet received the attention of the biologists. The reason as to how a pronounced hypocotyl is formed in certain cases carrying the cotyledons above the surface of the soil (that is, showing epigeal seedling growth) and how in other cases the cotyledons remain submerged inside the soil and the shoot emerges with its first leaves (that is, showing hypogeal seedling growth) has not yet been explained. Morphologically the hypocotyl region exists in the latter form, too, although much reduced (*5*).

The present investigation was undertaken when it was observed that, when seeds of *Phaseolus mungo* var. T-2 were treated with high concentrations of indole-3-butyric acid at a concentration of 100 to 200 ppm, there was a marked reduction of the hypocotyl—so much so that the seedlings in some cases appeared almost hypogeal in nature. The shortening of the hypocotyl was almost completely reversed by low concentrations of gibberellic acid, particularly at concentrations of 5 ppm.

Figure 1*A* shows the effect of various concentrations of indole-3-butyric acid on the length of the hypocotyl at various growth periods. Up to the third day after germination the increasing concentration of the acid showed an inhibitory effect on the length of the hypocotyl. From the fourth day onward, however, to the seventh and eighth days, the concentrations ranging from 1 to 25 ppm showed a promotive effect on the length of the hypocotyl over the control. This suggested that some substance produced by the cotyledons or the growing first leaves at this stage of growth interacted with the externally applied hormone to give this promotive effect and that during the first three days more auxin than the other substance was being produced so that the externally applied auxin raised this to the inhibitory level. If this were true, then the gibberellic acid alone, when given to the presoaked seeds, would give stimulation at the third day and no change or an inhibition of the hypocotyl length at the seventh or eighth day. This indeed has been found to be so. The application of gibberellic acid (GA_3) alone, given for 3 hours to the previously soaked seeds, gave values (in millimeters) on the third day as follows: control, 26.0 mm; 1 ppm GA_3, 27.7; 2.5 ppm GA_3, 29.1; 10 ppm GA_3, 17.4; 20 ppm GA_3, 21.3; and 50 ppm GA_3, 24.2. mm. On the seventh day the values were: control, 41.1; 1 ppm GA_3, 39.1; 2.5 ppm GA_3, 34.8; 10 ppm GA_3, 35.0; 20 ppm GA_3, 36.5; and 50 ppm GA_3, 40.0. Gibberellic acid indeed is known to give an additive effect with auxin in the growth of the pea stem sections (*6*). Higher concentrations of indole-3-butyric acid, like those of 50, 100, and 200 ppm showed marked inhibitions however.

A concentration of 100 ppm of indole-3-butyric acid was used as the inhibitory hormone concentration in further experiments for two reasons. First, this concentration did not result in the abnormal callus formation on the cotyledons, and, second, it was not toxic for the growth of the seedling and yet it resulted in marked inhibitions of hypocotyl length.

Figure 1*B* shows the effect of different concentrations of gibberellic acid when given to the seeds in combination with indole-3-butyric acid at a concentration of 100 ppm. The treatment was given for 3 hours. The results plotted are those obtained in two separate experiments. It will be seen that, although all the concentrations of gibberellic acid reverse the inhibition to a certain degree or the other, it is almost quantitatively reversed by a concentration of 5 ppm of gibberellic acid and at all the periods on which the growth measurements were made. Further it will be noted that the reversal has been almost complete not only in relation to length (Fig. 1*B*) but also in regard to the fresh and dry weights of the hypocotyl (Fig. 1, *C* and *D*).

Although the length of the hypocotyl is closely paralleled by changes in the fresh weight at 4 and 8 days of seedling growth, the dry-weight changes show an interesting result. Both the length and the fresh weight of the hypocotyl on the eighth day, in the case of 5 ppm of gibberellic acid given with 100 ppm of indole-3-butyric acid, is about 175 to 200 percent to that of the fourth day, the dry weight showing almost no change. This would indicate that growth during this period has been chiefly because of cell enlargement causing elongation of the cells of the hypocotyl and increase in the fresh weight; this indication fits in very well with the gibberellic acid effect.

The possibility of any such reversal of the inhibition with kinetin was then tested. The values of hypocotyl length obtained for kinetin concentrations of 1, 2.5, 5.0, and 10.0 ppm, when given in combination with indole-3-butyric acid at a concentration of 100 ppm, averaged about 5 mm in all the cases on the fourth day, exactly paralleling the figure obtained for indole-3-butyric acid alone. The hypocotyl of the untreated control seedling measured 20.4 mm. On the eighth day the values obtained were: control, 32.2 mm; 100 ppm of indole-3-butyric acid, 21.2 mm; indole-3-butyric acid plus kinetin, 18.6, 19.3, 21.7, and 24.0 mm, respectively, at kinetin concentrations of 1, 2.5, 5.0, and 10.0 ppm. The concentrations of kinetin used in these experiments did not reverse the inhibition of the hypocotyl produced by indole-3-butyric acid.

From these results it can be concluded that high auxin and probably very low gibberellic acid concentration in the germinating seeds would result in the hypogeal type of seedling growth, while low auxin and relatively high gibberellic acid concentration would result in the epigeal type of seedling growth. Indeed gibberellic acid is being considered as one of the naturally occurring growth regulators (*7*) since it has been extracted from numerous plants and from various types of plant tissues (*8*).

M. M. LALORAYA
S. A. NAQVI
Department of Botany, University of Allahabad, Allahabad, India

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Giant Desiccation Fissures on the Black Rock and Smoke Creek Deserts, Nevada

Abstract. Open fissures, from 100 to several hundred feet apart, that have produced polygonal patterns on the Black Rock Desert, Nevada, are believed to be giant desiccation cracks resulting from a secular trend toward aridity in the last few decades. Similar features on the Smoke Creek Desert probably have the same origin.

A system of open fissures that divides a part of the playa of the Black Rock Desert into large polygonal blocks was investigated in June 1960 and again October 1960 (*1*). The fissured area was photographed from the air in October 1960 (Fig. 1), when other extensive fissured areas on both the Black Rock and nearby Smoke Creek Deserts were observed.

The system of fissures on the Black Rock Desert that was studied on the ground commences about 20 miles north of Gerlach on the desert road between Gerlach and Summit Lake and extends northward about 5 miles along the northwestern margin of the playa. The system is 1 to 2 miles wide. The fissures range from less than an inch to about 2 feet in width; in general, the narrower fissures are open to the greatest depths (Fig. 2). The fissures appear to be vertical, and some are open to depths in excess of 4 feet. Minor irregularities in the fissure walls prohibit visual estimation of the depth of many of the narrow fissures. The fissures intersect to form an orthogonal network dividing the playa into blocks with edges from 100 to 250 feet long. The widest and oldest fissures, which are generally shallow because of slumpage of material into the opening, form a master network several times as large as the individual rectangular blocks which appear to have developed by progressive subdivision of the larger blocks.

The fissures on the Black Rock Desert are generally confined to the periphery of the playa, and the fissured areas are generally elongated parallel to the edge of the playa. In some fissured areas there is a preferred orientation of master fissures approximately parallel to the edge of the playa (see Fig. 1*A*), but in other areas no preferred orientation was noted.

The fissures are believed to be very recent; some fissures seem to be extending into unfissured ground at the present time (Fig. 1*B*). Faint drainage features in the fissured areas can be identified on 1:20,000-scale aerial photographs of the area northeast of Gerlach taken for the Soil Conservation Service from 10:00 to 10:20 A.M., 21 July 1954, and at 11:06 A.M. on 9 September 1954; however, fissures cannot be identified on these photographs. Although narrow fissures might not have produced wide enough shadows to be resolved on the 1954 photographs, the present fissures were clearly visible from the air between 9:30 and 10:00 A.M., 20 October 1960 (Fig. 1) and could be seen for distances of several

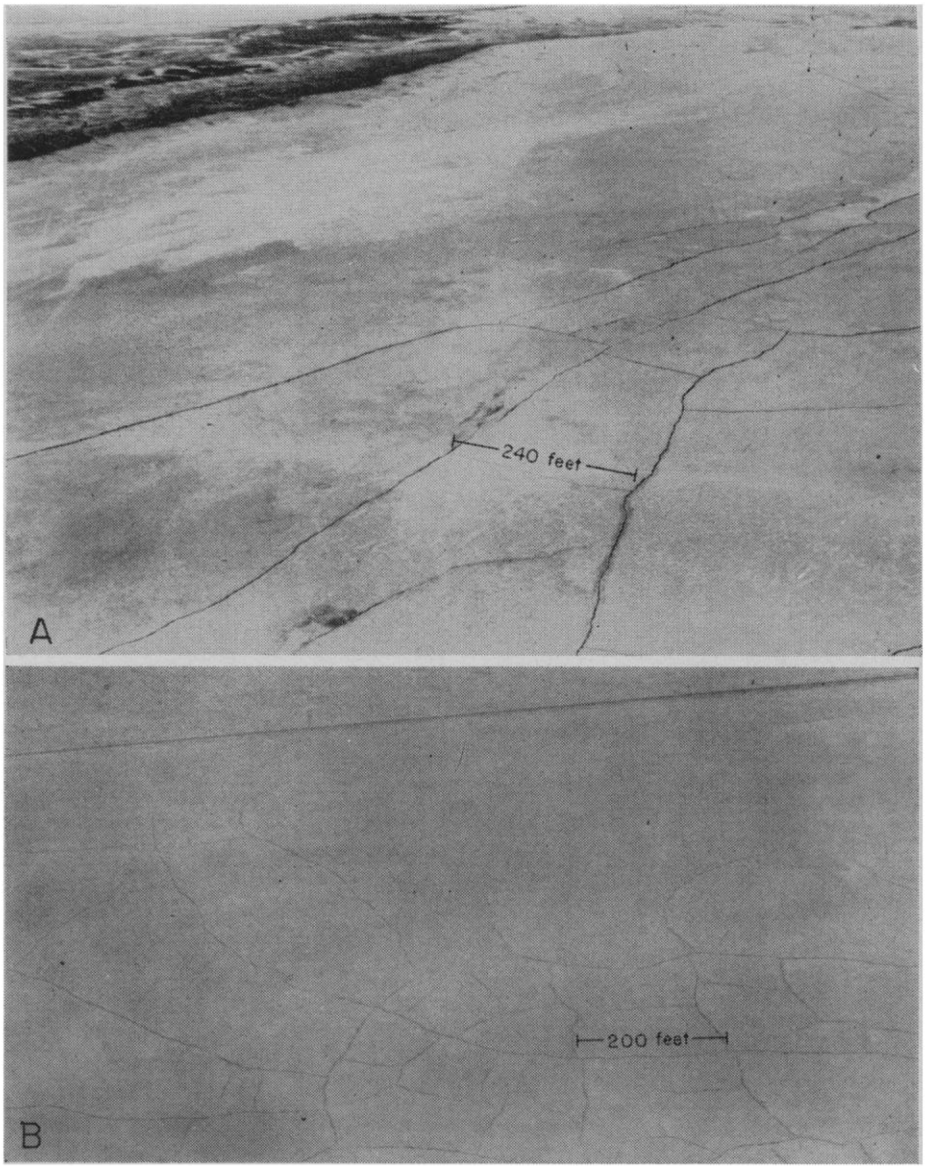

Fig. 1. Oblique aerial photographs of desiccation fissures on the Black Rock Desert, Nevada. Scale is approximate. (*A*) Master fissures approximately parallel to periphery of playa. (*B*) Master fissures extending from polygonal ground into unfissured ground.