Table 1. Spearman rank-correlation coefficients. D-1, D-2, and R-2 are defined in the legend to Fig. 1. Correlations in italics are split-half reliabilities (periods 1 + 3 versus 2 + 4).

	D-1	D-2	R-2
D-1	*.49**	.67†	.21
D-2		*.69†*	.54*
R-2			*.90†*

* Significant at the .05 level. † Significant at the .01 level.

confirms Holland's (see *3*, Fig. 9), indicating that we had succeeded in reproducing his conditions.

Using each observer's over-all performance in each session, we then performed the correlational analysis summarized in Table 1. The correlations show, first, that each measure was reasonably reliable (*9*). Second, the significant correlation between D-1 and D-2 may be interpreted as being due to the common "vigilance" factor in signal-detections. Third, the significant correlation between detections in the illumination-response session (D-2) and illumination-responses (R-2) also implies a common factor. The basic question is whether or not the latter factor is the same "vigilance" factor common to detections.

The answer lies in the correlation between detections in the session without illumination-responses (D-1) (which are governed in part by the "vigilance" factor) and the illumination-responses (R-2). The insignificant Spearman rank-correlation of 0.21 suggests that illumination-responses are not governed by a "vigilance" factor. A Kendall (*10*) partial-rank correlation, τ, is appropriate here to remove spurious correlations between D-1 and R-2 due to their common correlation with D-2. We found

$$\tau_{(D\text{-}1)(R\text{-}2).\,(D\text{-}2)} = -.09,$$

indicating the complete absence of a positive correlation and, by implication, of a "vigilance" factor in illumination-responses. Thus, except for the artifact introduced in Holland's procedure by making detections impossible unless signals and illumination-responses occur simultaneously, we cannot consider that illumination-responses govern detections, at least not detections as related to vigilance. On the other hand, Holland's results support the opposite causal relation, that detections control the rate of emitting illumination-responses.

Holland's work was inspired by the results of research on the relationship between schedules of reinforcement and operant behavior (see *4*), and it is appropriate to phrase our conclusions in the same terms. Presently available evidence permits the assumption that detections (not signals) are reinforcements. But detections are "scheduled" by the observer rather than by the experimenter, and the major problem in research on vigilance is how and why the observer produces these schedules. It is irrelevant for this problem (though certainly interesting) that the schedules, once produced, can control an operant like the illumination-response. The analogy with operant behavior is to the question of how an experimenter decides on particular schedules of reinforcement, because the observer is in the role of an experimenter arranging a schedule of detections.

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2 December 1960

Ion Uptake by Living Plant Roots

Abstract. By taking daily autoradiographs of a uniformly labeled soil in which plants are growing, patterns of actual ion uptake from the soil can be established. This technique can be used to study such influences on ion uptake as that of plant species ion diffusion, moisture and temperature stresses, and different physical, chemical, and biological properties of the soil.

Some investigators (*1*) have suggested that because of ion uptake the nutrient level is low in the soil in the vicinity of the root and a gradient exists out from the root into the surrounding soil. The exact nature of this gradient has not been established. Usually the average level of a nutrient in the soil after cropping, in conjunction with the uptake by the plant, has been

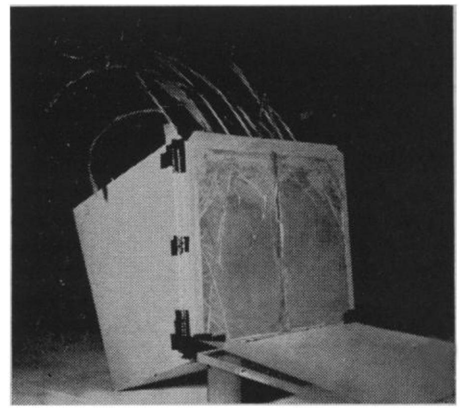

Fig. 1. Corn roots growing in uniformly labeled soil in a box designed to permit frequent taking of autoradiographs.

used as a measure of the absorption pattern. The following technique was devised to study the actual pattern of ion uptake.

Corn was grown in the specially designed box shown in Fig. 1. The front side of the plywood box was sloped so that the corn roots were forced to follow this open face. A 2-mil polyethylene film was stretched across the open side, confining the soil. A ⅜-inch Plexiglas door, hinged at the bottom, could be moved up to make contact with the plastic film, or lowered, as pictured in Fig. 1, to secure the soil. A ⅛-inch layer of soil, uniformly labeled with rubidium-86, was spread next to the polyethylene film. The remainder of the box was filled with unlabeled soil. The uniformly labeled soil was prepared by stirring 100 ml of solution, containing approximately 150 μc of rubidium-86, with 250 g of air-dry 50-mesh sieved soil. After air-drying, the labeled soil was ground and mixed with a mortar and pestle.

Germinated corn was planted 1½ inches back from the polyethylene film. When the box was placed in the greenhouse, the open side was shielded from the sunlight with aluminum foil. A 1-inch layer of pearlite was placed on the top of the soil to prevent evaporation, and the soil was kept at a moisture content of approximately 20 percent.

Roots are shown growing in the labeled soil against the plastic film in Fig. 1. Autoradiographs were obtained by taking the box into a photographic darkroom and there blocking it up so that the open side would be vertical (*2*). Blocking was necessary to avoid disturbing the labeled soil. In total darkness a 10- by 12-inch no-screen x-ray film was placed on the Plexiglas door as shown in Fig. 1. The door was tightly closed, pressing the x-ray film against the polyethylene film. The film was exposed for 1 hour on the first day with an approximate 10-minute increase in exposure time daily to allow for absorption, diffusion, and decay of the isotope.

Figure 2 is part of an autoradiograph obtained by this method. The dark background area is the uniformly labeled soil. The whiter areas are soil areas from which rubidium-86 has been removed by absorption into the plant root. The dark lines are caused by rubidium-86 concentrated in the tips and vascular systems of the roots, which has not yet been translocated to the plant top.

Because of the construction of the box, photographs, as well as autoradiographs, could be made of the roots growing in the soil. Both by visual observations of the autoradiographs and photographs and by densitometer tracings of the auotradiographs, the following conclusions have been drawn about the pattern of rubidium-86 uptake by the corn plant.

For corn from 0 to 3 weeks old. rubidium-86 absorption occurred initially through the root tip, and rubidium was translocated into the corn plant. Subsequently, continued uptake occurred all along the root, depleting the soil of rubidium-86 almost entirely in the immediate vicinity of the root. Diffusion of rubidium-86 also occurred, which replenished the absorbed rubidium-86. Diffusion was observed by cutting a root, thereby killing it, and finding that the area of absorption was refilled with rubidium-86 within 9 days.

By using the technique described in this article, it was possible to establish the actual pattern of rubidium-86 absorption from the soil by corn roots. This technique is being applied to a further investigation of the relationships between plant roots and the soil (*3*).

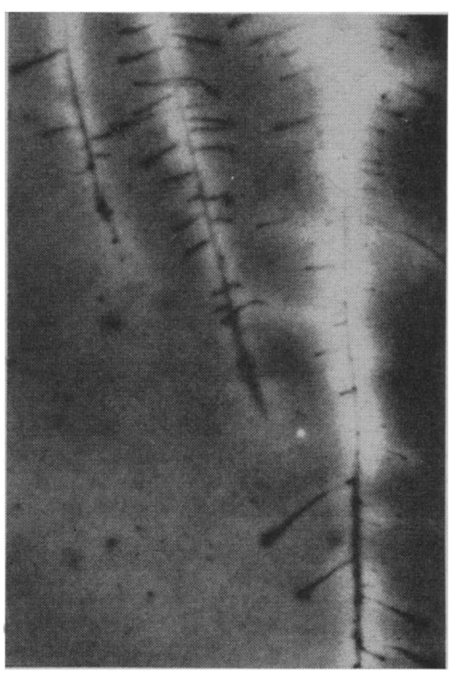

Fig. 2. Autoradiograph showing the removal of rubidium-86 from soil by the roots of 12-day-old corn plants (approximately two thirds of the actual size).

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3. This investigation was part of a thesis submitted in partial fulfillment of the requirement for the Ph.D. degree by the senior author.

5 December 1960

Coesite from Wabar Crater, near Al Hadida, Arabia

Abstract. The third natural occurrence of coesite, the high pressure polymorph of silica, is found at the Wabar meteorite crater, Arabia. The Wabar crater is about 300 feet in diameter and about 40 feet deep. It is the smallest of three craters where coesite has been found.

Since the discovery of natural coesite, the high-pressure polymorph of silica (*1*), at Meteor Crater, Arizona, the search for it in sintered materials of impact and other possible origins, such as tectonic or volcanic, has been continued in the laboratories of the U.S. Geological Survey. The work is a part of a program of crater investigations sponsored by the National Aeronautics and Space Administration. During the course of this work, a second occurrence of natural coesite was found in *suevit*, a tuff-like rock, from the Rieskessel in Bavaria, Germany (*2*). In this paper (*3*) we report a third occurrence of natural coesite, from the iron meteorite impact crater of Al Hadida.

The Wabar crater near Al Hadida (21°30′N, 50°28′E) is in a quartose sandstone of unknown age, partly buried by drift sand in east-central Arabia. It is circular in shape, and according to Philby (*4*) it is about 300 feet in diameter and about 40 feet deep. According to Spencer (*5*) large amounts of black glass (the Wabar glass), partly vesicular and partly dense, with inclusions of fractured white sandstone, are found at the crater. The presence of silica glass is also mentioned by Spencer.

Two specimens of coesite-bearing material collected from the Wabar crater by Virgil Barnes, Bureau of Economic Geology, University of Texas, have been examined in the U.S. Geological Survey laboratories. One specimen consists of white siliceous material about 1 cm across, enclosed in black glass; the second was a piece of fractured sandstone about 4 cm across (Fig. 1).

Both specimens were crushed to reduce them to individual mineral grains, and fractured quartz grains were handpicked. These, as well as bulk specimen powders, were studied by x-ray diffraction methods. Film patterns of the bulk powders showed only one very weak reflection at 28.85 2θ (Cu $K\alpha$), which indicates the possible presence of coesite.

The x-ray film of the hand-picked, fractured quartz grains showed many more weak reflections of coesite than that of the bulk sample. We have since been able to separate relatively pure coesite and have obtained an x-ray pattern with no indication of quartz. The coesite was separated by treating 5.4 g of minus 270-mesh material with 300 ml of a water solution of 5 percent hydrofluoric acid and 5 percent nitric acid at room temperature for 3 days (coesite is considerably less soluble than quartz and glass in weak solutions of hydrofluoric acid); the product was filtered, and the treatment was repeated on the residue for an additional 2 days; then it was filtered again, and the relatively pure coesite was washed and dried.

X-ray patterns of coesite from Al Hadida agree in every detail with those of synthetic coesite and natural coesite from Meteor Crater, Arizona. Optically it is indistinguishable from the Meteor Crater coesite; it is extremely fine, with grains generally about 5μ or less. It has a mean index of refraction of 1.595 and very low birefringence.

The Wabar crater is by far the smallest of the three craters at which coesite has been found. It is estimated that the specimens from Al Hadida contain about 1 percent coesite. Because the

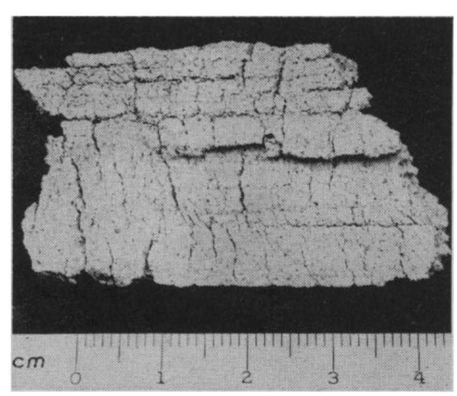

Fig. 1. Fractured coesite-bearing sandstone, showing bedding and steeply inclined fractures, from the Wabar crater.