genesis in the uniform parenchymatous cells of these older cultures, by adding coconut milk (10 percent by volume), carrot root extracts, or mixtures of natural and synthetic growth regulators to the medium, occasionally resulted in the development of embryos. However, these few embryos are now believed to have been the result of encouraging the growth of a few proembryos carried over from earlier subcultures, rather than the result of inducing some change in "noncompetent" cells.

These findings indicate that cells which are embryologically competent can serve as the starting point in a developmental pathway in which the morphogenetic controls are largely internal. In other words, developing carrot embryos do not appear to require a complex array of exogeneous nutrients or an environment with precise chemical and physical gradients. The factors leading to the "competency" of the zygote or of certain cultured cells are unknown (*9*).

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6. The term suspensor here refers to those cells of the proembryo which are not incorporated into the embryo proper, and which thus have the same topological significance as the suspensor cells of seed embryos. Virtually nothing is known of the function of the suspensor, other than its possible role as a device for pushing the embryo into the endosperm, so no real homology can be established.
7. We have adopted a modification of the terminology of Soueges, in which the term proembryo refers to any developmental stage preceding cotyledon initiation [R. Soueges, *La Differenciation* III. *La Differenciation Organique* (Hermann, Paris, 1936)]. The term preglobular proembryo refers to the histologically undifferentiated condition preceding the initiation of protoderm, and globular proembryo refers to the stage following protoderm initiation and preceding cotyledon development.
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9. Since this paper was submitted, we have found that for embryogenesis to proceed in vitro the presence of ammonium ions is essential. Callus will grow indefinitely on a medium containing nitrate alone, but segmentation patterns typical of proembryos will not form. Preliminary experiments indicate that glutamine, aspartate, a mixture of amino acids, or coconut milk will not substitute for the ammonium requirement.
10. This work was done during the tenure of an NIH fellowship (W.H.) and with the aid of NSF grant GB-1936 to D.F.W.

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Brightness Discrimination in the Collared Lizard

Abstract. *Eight collared lizards were tested on a modified Lashley apparatus for brightness discrimination. The animals reached the criterion level of learning in 335 trials and exhibited behavior on the choice platform comparable to that of the rat presented with a similar problem. The pattern of latency appears to be atypical in the lizard, since there was little decrement throughout the learning period.*

Snakes and turtles have served as subjects in most studies of the problem-solving abilities of reptiles. Although various aspects of behavior have been studied in lizards, very little is known about their ability to modify stereotyped behavior by learning. Here we report the behavior of eight collared lizards (*Crotaphytus collaris*) when presented with a brightness-discrimination problem.

The collared lizard occurs in rocky desert areas over much of the western United States, and its ecology is well known (*1*). It is particularly suitable for experimentation; it is large enough to be handled with ease, and its pugnacious temperament at the time of capture is readily transformed into docility after brief periods of handling. Most important, it shares with other heliothermic reptiles the tendency to maintain, by behavioral means, a relatively constant body temperature during periods of activity. Thus the question of motivation and reward, so often a problem with ectothermic animals, is resolved by the use of heat, for which the animals show no apparent satiation with repeated exposure.

Our lizards were collected from Townes Pass, Inyo County, California, at elevations between 700 and 1100 m. The mean body temperature of the experimental animals in their natural habitat was 37.1° ± 1.8°C, which approximates the optimum temperature for collared lizards as indicated by Fitch (*1*). A temperature of 40°C, which is often encountered by the lizards in their natural habitat, was provided as a reward in the experiments. Exposure to this temperature for a period of 3 minutes causes a significant rise in body temperature. The five male and three female lizards used in the study varied in snout-vent length from 70 to 90 mm with an average length of 80 mm. The animals were sexually mature, and all either maintained or gained weight while in captivity.

The lizards were housed in screened wooden cages with sand and rocks on the floor. They were exposed to heat for 3 hours in both the morning and evening. The heat was provided by 250-watt infrared lamps suspended 105 cm above the cage floor. Fluorescent lamps were usually on during the day and the room was dark at night, but there was no attempt to regulate the photoperiod. Food, consisting entirely of meal worms (*Tenebrio* larvae) during the period of training, was given only when the lizards were in the experimental apparatus. Water was provided in the home cages and was available in the small glass tanks used to hold the animals during the trial periods.

The experimental apparatus was a modified Lashley discrimination stand (Fig. 1), 95 mm high, covered with clear plastic 3 mm thick to prevent escape of the animals. A hardware cloth ramp led up to a "choice platform" from which the animal could view the two goal boxes; the floor of the platform was covered with neutral-colored sandpaper which provided a tractional surface. Alleys separated by a 30-deg angle extended to the goal boxes. One alley and the positive goal box to which it led were lined on all surfaces with sandpaper painted with white enamel; the negative goal box and its alley were similarly lined in black. Attached to the floor of both alleys were two electrode plates extending from wall to wall. The electrodes across the white alley were inactive. Those across the black alley were powered with a

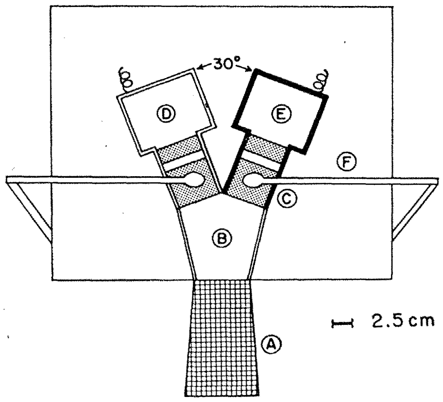

Fig. 1. Diagram of discrimination apparatus. *A*, Screen ladder; *B*, choice platform; *C*, alley with plate electrodes; *D*, positive goal box; *E*, negative goal box; *F*, lamps extended over alleys.

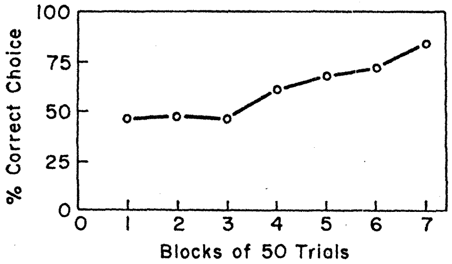

Fig. 2. Mean percentage of correct choices for eight collared lizards presented with a brightness-discrimination problem.

shock generator (*2*) to deliver 45 volts a-c. The alleys offered no cues except brightness, and both were at room temperature. Immediately beneath the floor of the white box was a heated plate which consisted of a length of nichrome wire cemented between two sheets of glass and maintained at 40°C by an autotransformer (*3*). A 7-watt bulb was suspended 13 cm above the center of each alley and directed into the goal boxes. The goal boxes with their alleys were interchanged at random; the white was always the positive (rewarded) goal. Collared lizards used in an earlier pilot study exhibited a marked preference for the black goal box.

The animals were given five trials a day for 5 days a week immediately after the morning heat period. The minimum intertrial interval was 3 minutes. Between trials the eight animals were kept together in a glass tank containing 6 mm of water so that their normally dry skin would become an adequate conductor. Placed upon the hardware cloth ramp, each lizard ran quickly up to the top and stood upon the platform, turning its head first toward one goal box and then toward the other. Such head-turning at a choice or decision point is what Muenzinger (*4*), Tolman (*5*), and others have called vicarious trial and error. If the animal went into the white alley and goal box it was given a meal worm and allowed to stay on the hot plate for 3 minutes. Motivation and reward seemed adequate since the lizards with remarkable consistency rapidly attacked and consumed the worm and then flattened themselves against the warm floor. In some instances it appeared that heat was the preferred reward since no lizard failed to flatten itself upon the hot floor even on occasions when the worm was not eaten. If the animal entered the black alley and goal box, it received a shock of approximately 45 volts a-c with an average of 0.4 to 0.6 ma. In response to this intensity of shock the lizard jumped, hissed, and scratched at the top of the goal box in an attempt to escape. The shocked males exhibited aggressive behavior similar to that described by Greenberg (*6*), depressing the gular region, posturing, and sometimes actually attacking when we removed them from the box. Ulrich (*7*) reported similar fighting responses to shock in other vertebrates. Immediately after the shock the lizards were placed in the glass tank.

The collared lizard is extremely sensitive to noise and movement. To minimize distractions during the trials we sat behind a screen. Latency (time in seconds on the platform), number of vicarious trials and errors (a turn of the head toward one goal box followed by a turn of the head toward the other goal box equals one vicarious trial and error), and the number of correct choices were recorded. The criterion for learning was 80 to 100 percent for three consecutive days.

Figure 2 indicates the course of learning. The scores are plotted as the mean percentage of correct choices for each successive 50 trials. A t-test of difference scores was used to compare the mean scores for the first 10 days and the mean scores for the last 10 days—that is, the first and last 50 trials. With 7 deg of freedom t (Student's t-value) was 6.08 with $p < .01$. In the early stages of this study we found that for approximately 200 trials, using only positive reinforcement (heat and worms), the average number of correct responses was only 33 percent. The strong preference for black is evident in these scores. Negative reinforcement was then added and after 150 trials with shock the scores began to increase consistently. In comparable studies with turtles there was no initial brightness preference on either a gray and white (*8*) or a black and white (*9*) discrimination problem, and learning in each case was faster than in our study. The acquisition of such a discrimination by these lizards is a slower process than for laboratory rats who, on a similar apparatus, with no shock, mastered the problem in 105 trials in a pilot study by one of us. The course of latency (Fig. 3) for the lizards bears a remarkable resemblance to that for rats designated in a recent study (*10*) as "slow learners" on a black-white discrimination problem and differs sharply from most decremental latency curves established for vertebrates. The head movements of the lizards prior to proceeding into a goal box were similar to those exhibited by a wide range of vertebrates at a point of choice (*11*). Figure 3 indicates the increase in such vicarious trial-and-error behavior during the course of learning the discrimination problem and lends support to Tolman's assertions (*12*) regarding the positive correlation of vicarious trial and error to acquisition.

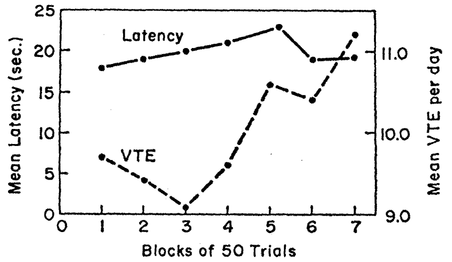

Fig. 3. Mean latency and mean frequency of vicarious trials and errors (*VTE*) for eight collared lizards during the course of learning the brightness-discrimination problem.

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