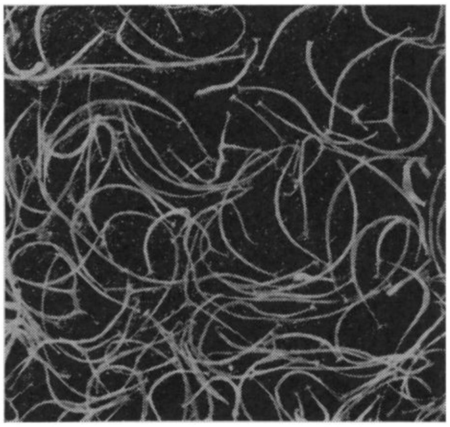

Fig. 2. Colony of "mutants" derived by budding of normal-appearing heterocytes (approximately same size).

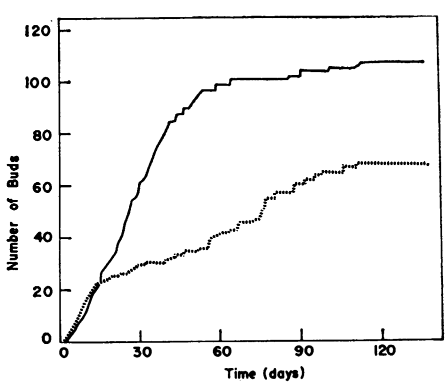

Fig. 3. Budding rate of two heterocytes resembling normal hydra.

were carried out as follows. As a daily procedure, two normal-appearing heterocytes were fed excess *Artemia* nauplii (*1*), their culture solution was changed twice, and the number of buds they produced was recorded. Both animals budded at a normal rate for at least 2 weeks (Fig. 3). At that time one animal (dotted line) became slightly larger, and started to take on the appearance of a mutant. This transforming animal continued to bud, but at a slower and irregular rate. After a month, budding ceased and the once normal-appearing heterocyte was gradually transformed, like the mutant, into a multipolar animal. This multipolar animal then slowly divided into six monopolar mutant-like animals (*3*), a few of which sporadically gave off a number of small bud-like individuals. After 100 days virtually all "bud" production ceased, with the mutant phenotype finally dominating the resultant monopolar animals.

The other heterocyte (solid line) continued to give off buds at a constant rate for about 40 days before it began undergoing a similar transformation. The monopolar mutant-like individuals derived from this normal-appearing heterocyte showed fewer latent bursts of budding activity than did the individuals derived from the other.

These experiments are but two of more than 25 conducted, in which the normal-appearing heterocytes always became mutant. The rate at which this transformation took place probably depended upon the number and location of mutant cells in the original heterocytes (*7*). The mechanism underlying this transformation remains unknown at this time.

The results of these experiments (Table 2, Fig. 4) demonstrate two properties of mixed populations of somatic cells: cellular segregation and heterocytic dominance. These two phenomena, as they occur in hydra, may have broad biological significance. For example, with respect to development, we have a system whereby cells of one set of inheritable characteristics can exert their developmental propensities over those of another, and can be expressed in the phenotype of the animal. With reference to evolution, the eventual dominance of mutant somatic cells may play a major role in the evolution of metazoan species reproducing solely or primarily through asexual reproduction. Lastly, the hydra heterocyte allows us to study a system in which mutant somatic cells can metastasize throughout an animal and eventually dominate the host tissue in a manner analogous to like processes of some tumors.

HOWARD M. LENHOFF

Laboratory for Quantitative Biology and *Zoology Department, University of Miami, Coral Gables, Florida*

References and Notes

1. W. F. Loomis and H. M. Lenhoff, *J. Exp. Zool.* **132**, 555 (1956).
2. L. Muscatine, in *The Biology of Hydra: 1961*, H. M. Lenhoff and W. F. Loomis, Eds. (Univ. of Miami, Coral Gables, Fla., 1961), p. 255.
3. This slow asexual division of a multipolar animal into monopolar animals is not "budding," which refers to a specific, rapid, developmental process of asexual reproduction in hydra.
4. M. Filosa, *Amer. Naturalist* **96**, 79 (1962).
5. A hydranth, as used in this context, is defined in H. M. Lenhoff and W. F. Loomis, *J. Exp. Zool.* **134**, 171 (1957).
6. W. F. Loomis, *ibid.* **126**, 223 (1954).
7. It should be kept in mind, however, that in cases of heterocytes made from other types of mutants, it may be possible for the normal phenotype to dominate.
8. O. Lowry, N. Rosebrough, A. Farr, R. Randall, *J. Biol. Chem.* **193**, 265 (1951).
9. O. Lowry, *ibid.* **140**, 183 (1941).
10. Supported by grants from the USPHS (GM 11226-02) and the Florida Division of the American Cancer Society, and by an investigator award of the Howard Hughes Medical Institute. This work was presented at a meeting of the American Society of Zoologists, Knoxville, Tenn., 1964.

18 February 1965

Sonar System of the Blind: Size Discrimination

Abstract. *Measurements were made of the ability of four blind subjects to use echoes to discriminate between objects of different sizes placed in front of them. Threshold estimates indicate that objects with area ratios as low as 1.07/1 could be discriminated.*

Kellogg (*1*) demonstrated that two blind subjects using information from echoes could detect differences in the sizes of standard objects placed in front of them. He did not, however, obtain measurements as to how fine a discrimination of this nature could be made. We have tested the ability of a group of blind subjects under uniform testing conditions to make size discriminations by using echoes. Measures were obtained as to how much of a difference in size must exist between two similarly shaped targets before one is judged as larger or smaller than the other. The echo-information was obtained from vocalizations produced by the subjects. The results obtained can be said to represent one measure of echo-acuity of the blind.

The subjects were four blind males, 20 to 30 years old. Each had been blind for at least 5 years and none had any spatial vision. Their hearing had been tested and found essentially normal. The subjects had received previous echo-detection training during earlier experiments and had developed their own echo-producing vocalization which they emitted when seeking or identifying targets suspended in front of them. The vocalizations ranged from sharp tongue clicks to elongated "S" sounds.

Testing was done in a specially constructed room. It was relatively isolated from noises outside the laboratory and the walls, ceiling, and floor were covered with sound absorbing materials. Though not anechoic, the room provided a relatively constant auditory environment in which to perform the tests. The average sound level in the room was 43 decibels on the C scale of a sound level meter with reference pressure 0.0002 dyne/cm^2. The apparatus used to present the circular sheet-metal targets to the subject extended down from a cupola above the room. These disc-shaped targets were raised and lowered on a metal rod by an experimenter in the room above. Subjects were seated in a testing chair

Table 1. Ratio of the area of the threshold target to that of the standard target at three distances for each subject.

Distance (inches)	Subject			
	CB	DB	WG	DD
24 (61 cm)	1.11/1	1.08/1	1.10/1	1.23/1
36 (91 cm)	1.08/1	1.12/1	1.07/1	1.22/1
48 (122 cm)	1.09/1	1.08/1	1.12/1	1.10/1

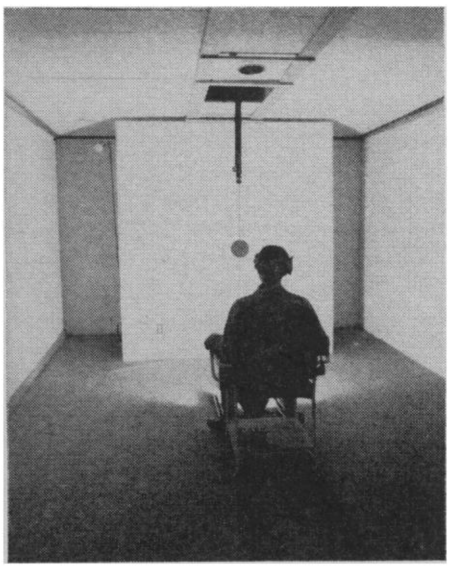

Fig. 1. Room used for testing, with subject and apparatus in position for a judgment.

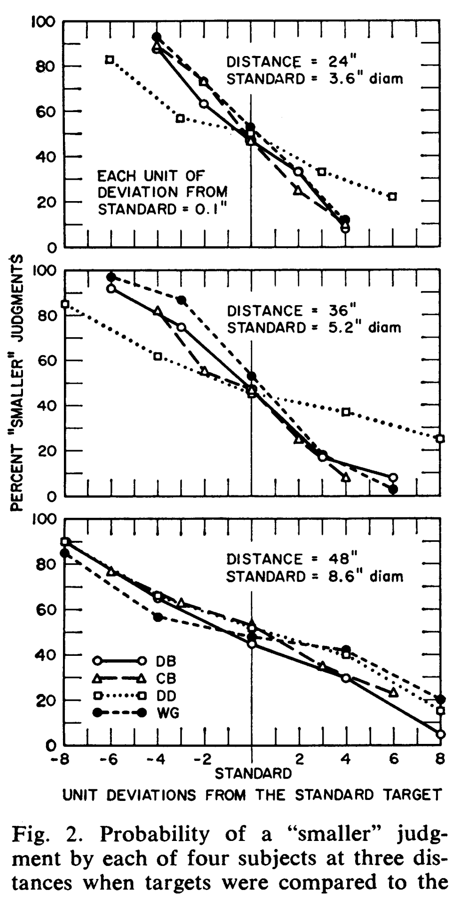

Fig. 2. Probability of a "smaller" judgment by each of four subjects at three distances when targets were compared to the standard.

(Fig. 1) which could be adjusted for the required heights and distances from the target. White noise was provided between trials in order to mask possible undesirable sound cues.

The subjects were tested at three distances from the targets: 24 inches (60.96 cm), 36 inches (91.44 cm), and 48 inches (121.92 cm) so that information on the effect of distance and auditory angle upon the size discrimination could be obtained. At each distance, a range of five target sizes was presented to the subject by the method of constant stimuli. The middle-sized target of the range was designated as a standard stimulus. This standard was randomly compared with itself and each of the other targets until each pairing had occurred 60 times. The order of presentation was counterbalanced with the standard occurring first and second on an equal number of trials. The subjects were instructed to emit their typical echo-detection noise upon presentation of each target and to make a judgement as to whether the second target of the pair was "larger" or "smaller" than the first. If, therefore, this second target seemed larger than the first, the subject's response were "larger," and vice versa.

The subjects were trained briefly with target discs which were much larger or smaller than the standard. As their performances improved this size difference was reduced until five targets were found which offered a good test of ability. Each range of targets was composed of: (i) a middle target or standard; (ii) two targets which deviated from the standard by plus and minus a given number of units in diameter (each unit equals 0.1 inch or 0.254 cm); and (iii) two targets deviating plus and minus twice as many units as in (ii). The actual range of difference in targets was governed by the distance of a given subject from the target and his skill at the task.

Figure 2 relates target size to the probability of a "smaller" judgement by each subject at the three distances. As the distance of subjects from the targets increased, the amount of deviation from the standard target necessary for the change in size to be perceived increased.

An estimate of the minimum amount of increase or decrease in target size which would be just noticeable may be made by calculating the standard deviation of the "smaller" judgements for a given size range (*2*). From this value an estimate can be made of the size of the target just perceptibly larger or smaller than the standard. This hypothetical target is referred to as a difference "threshold" target. Such a threshold target for each subject at each distance was calculated and the ratios of the areas of these targets to the standard target are shown in Table 1. The ratio of the size of the threshold target to the standard was relatively constant regardless of distance. This leads to the hypothesis that the difference threshold for size by echo-detection is a constant size ratio.

We conclude that the human ear is capable of making relatively fine size discriminations from echo-information. The precise stimulus parameter on which these discriminations are made is as yet unknown. Preliminary evidence from current experimentation leads to the hypothesis that echo intensity is a probable cue. The degree of acuity for the task reported here is equal to that of thresholds of visual differences reported for monkeys (*3*) and sea lions (*4*), both regarded as animals with fairly good vision. Sighted humans, however, had no difficulty in making the visual discrimination among targets in this task.

CHARLES E. RICE
STEPHEN H. FEINSTEIN
Stanford Research Institute, Menlo Park, California 94025

References and Notes

1. W. N. Kellogg, *Science* **137**, 399 (1962).
2. J. P. Guilford, *Psychometric Methods* (McGraw-Hill, New York, 1954).
3. H. Klüver, *Behavior Mechanisms in Monkeys* (Univ. of Chicago Press, Chicago, 1957).
4. R. J. Schusterman, W. N. Kellogg, C. E. Rice, *Science* **147**, 1594 (1965).
5. Supported by grant NB-04738 from the National Institute of Neurological Diseases and Blindness. Our appreciation is expressed to Dr. R. J. Schusterman for his consultation throughout the experiment.

22 January 1965

Galvanic Skin Reflex in Newborn Humans

Abstract. *Psychophysiological recordings of reactivity to light and sound and to tactile and olfactory stimulation demonstrate that the galvanic skin reflex is an observable and functional mechanism in the 20- to 67-hour-old newborn human.*

Though originally purported by Peiper (*1*) to be undeveloped until 12 months after birth, the galvanic skin reflex (GSR) was subsequently dem-