References and Notes

1. N. Adler, *J. Comp. Physiol. Psychol.* **69**, 613 (1969); F. A. Beach, in *Nebraska Symposium on Motivation*, M. R. Jones, Ed. (Univ. of Nebraska Press, Lincoln, 1956); B. L. Hart, *J. Comp. Psychol.* **65**, 453 (1968).
2. S. Siegel, *Nonparametric Statistics* (McGraw-Hill, New York, 1956).
3. G. Bermant, *J. Comp. Physiol. Psychol.* **57**, 398 (1964); K. Larsson, *Anim. Behav.* **7**, 23 (1959); K. Larsson, *Behaviour* **16**, 66 (1960).
4. K. Larsson, *Conditioning and Sexual Behavior in the Male Albino Rat* (Almqvist & Wiksell, Stockholm, 1956).
5. P. Marler, *J. Comp. Physiol. Psychol.* **71**, 1 (1970).
6. N. Adler and J. Hogan, *Anim. Behav.* **11**, 351 (1963).

7. This research was funded by NIH grant HD 04522 to N.A. Manuscript preparation was supported by NIMH grant MH 22881 to A.S.

11 February 1974

Solar Energy by Photosynthesis: Manganese Complex Photolysis

In a recent article (1) a reference was made to the photolysis of a binuclear manganese complex [reference 20 in (1)] in which oxygen evolution was measured by a Teflon-coated silver-gold electrode [figure 7 in (1)]. In an attempt to quantify this effect it has become apparent that most, if not all, of the change in slope of the apparent oxygen concentration is the result of a small temperature change (0.4°C) on the oxygen permeability of the membrane. Upon illumination in a visible band the thermostated sample solution is warmed slightly by thermal de-excitation of the excited state of the complex. This in turn increases the diffusion rate of atmospheric oxygen across the Teflon membrane, causing a change in the apparent oxygen concentration as sensed by the electrode.

In light of these results, we are seeking alternate evidence for oxygen evolution by the binuclear manganese complex.

S. R. Cooper
M. Calvin
Laboratory of Chemical Biodynamics, University of California, Berkeley 94720

References and Notes

1. M. Calvin, *Science* **184**, 375 (1974).

2. This work was performed under the auspices of the U.S. Atomic Energy Commission.

17 June 1974

Ecological Genetics and Natural Selection in Mollusks

Jones (1) has raised again the controversial question as to whether polymorphism in shell color and pattern in the land snail *Cepaea* is correlated with climate. He provides evidence suggesting that in *C. nemoralis* there is a correlation between gene frequencies at the shell color locus and mean summer temperature, but he could find no correlation with climate for other loci. Following earlier workers, Jones acknowledges that there is a correlation between polymorphism and habitat in some (but not all) English populations of *C. nemoralis*, and that there are situations in which frequency-dependent selection by predators occurs. The possibility of heterozygote advantage is also entertained. There remain, however, many inexplicable variations in the frequency of the phenotypes that are not correlated with obvious environmental features. These "area effects" occur over what are claimed to be ecologically similar environments, and thus far have defied explanation.

There is an extensive literature on polymorphism in *Cepaea*, some of it cited by Jones (1), but two features of the ecology of the snails, population size and population density, both potentially important in the interpretation of genetic diversity, have been neglected by most workers. Estimates of population size would seem desirable if genetic drift is to be accepted or rejected as a major factor affecting gene frequencies, and estimates of population density would seem relevant in view of the correlations that have already been established between density and polymorphism in other species of molluscs.

Thus in *Donax rugosus*, a common bivalve of the sandy shore in West Africa, polymorphism correlates well with population density, the diversity of phenotypes being greater at high as compared to low densities (2). In the African land snail *Limicolaria martensiana*, polymorphism also increases with density, and in the Kampala area of Uganda there is little or no polymorphism where the snails exist at densities of less than 1 per square meters; but where they occur at densities in excess of 100 per square meter, polymorphism is maximal (3).

The association of genetic diversity with population density in *Donax* and *Limicolaria* can be interpreted theoretically in terms of frequency-dependent apostatic selection by predators like birds. Such predators are likely to acquire search images of their prey; and at high densities where predation is heavy, phenotypes that stand out or contrast may be at a selective advantage.

That there are variations in population density in *Cepaea nemoralis*, even in an apparently uniform environment, has been demonstrated (4). If, then, density can vary, why should not the genetic diversity also be affected? Perhaps, too, what appears to us as a uniform environment is to a snail immensely varied; this would certainly explain variations in density over quite small areas. I do not mean to imply that variation in population density (and indeed in population size) are necessarily of profound importance in understanding polymorphism in *Cepaea*, but it would certainly be worth looking to see if there are density effects.

D. F. Owen
66 Scraptoft Lane, Leicester, England

References and Notes

1. J. S. Jones, *Science* **182**, 546 (1973).
2. D. A. S. Smith, *J. Zool. Lond.* **164**, 429 (1971).
3. D. F. Owen, *Science* **140**, 666 (1963); *Heredity* **20**, 312 (1965). E. B. Ford [*Ecological Genetics* (Methuen, London, 1971)] misinterprets polymorphism in *Limicolaria* by stating that it is correlated with population size rather than with population density.
4. C. B. Goodhart, *J. Anim. Ecol.* **31**, 207 (1962).

1 February 1974; revised 27 March 1974

Owen suggests that population density may have an effect in controlling gene frequencies in populations of *Cepaea* and of other mollusks. In the light of the recent important theoretical work (1) on possible relations between density and the genetic structure of populations this suggestion is an interesting one. Some information is already available on population density in *C. nemoralis* (2), and it is clear even to the casual collector that this species shows enormous local variations in abundance. However, it is difficult to estimate real population densities in many land mollusks (including *Cepaea*) by simply making collections because very frequently a large proportion of the population is buried beneath the surface of the