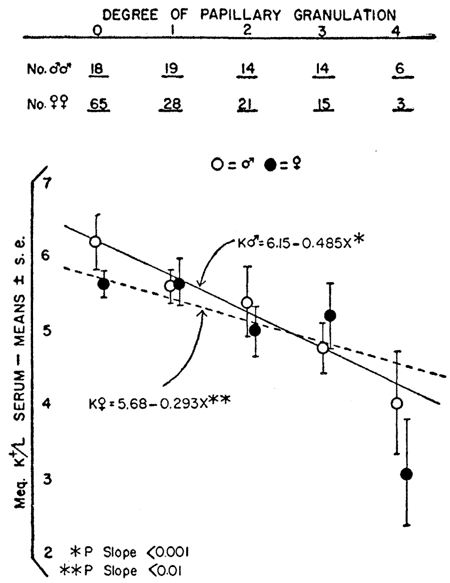

Fig. 1. Degree of granulation in the renal papillae on a basis of 0 to 4 plotted against serum potassium levels for 71 male and 132 female woodchucks.

random sample of 346 animals (*5*). Comparisons between serum potassium and degree of granulation were possible for 203 of these for which there were sections through the papillary tips. Muscle potassium was not measured.

Serum potassium levels declined significantly as the degree of granulation increased in both sexes (Fig. 1). However, the relationship was poorer in the females, as indicated by the lower slope and lower degree of significance, in spite of a much larger sample size. The adjusted mean serum potassium levels of the two regressions were not different (5.15 for males and 5.45 for females), but the difference between the slopes approached significance ($P < 0.10$). Pregnancy and lactation may account for the greater variability in the females. Nevertheless, use of the degree of papillary granulation as a rough index of the degree of potassium deficiency is justified by the significant correlation between papillary granulation and serum potassium levels in both cases.

Renal papillary granulation is marked when the woodchucks emerge from hibernation (Table 1). It then declines exponentially through June, remains at a low level through August, and begins to increase again to reach a relatively marked degree by December (Table 1). The pattern of change in the degree of granulation throughout the year was the same for every year, from 1956 through 1960. During February and March the degree of granulation is significantly greater in males than it is in females (Table 1), but by April the values for both sexes were the same. These differences are accounted for by the fact that males begin to emerge from hibernation about a month before the females, although the mid-points of emergence are about 2 weeks apart. During this period there is little or no food available, and the gastrointestinal tracts of the males invariably are empty (*6*). Consequently, the males are living entirely on stored fat then and, to a lesser extent, afterwards (*6*). On the other hand, the females emerge at about the time food becomes available. The greater degree of granulation and, therefore, presumably, potassium deficiency in males apparently is due to continuing potassium losses without dietary repletion during the 2 to 4 weeks immediately following hibernation. On the other hand, it is clear that the granulation begins to develop immediately prior to hibernation and continues to progress during, and particularly after, hibernation when the animals again are depending on stored fat without ingesting food and, consequently, potassium.

From the preceding evidence, it appears that woodchucks experience an uncompensated loss of potassium during the period of the year in which they subsist largely on stored fats; that is, immediately prior to and during hibernation and, for males, during the immediate postemergence periods. The loss apparently is progressive and cumulative until repletion begins early in March. The loss of potassium could be aggravated by a relatively increased activity of sodium and water-retaining endocrine mechanisms, such as a relative increase in aldosterone secretion, during hibernation. However, this aspect of the problem has not been explored. The adrenal glands in these animals weighed the least during hibernation and increased in weight every year from the end of hibernation until June, apparently as a result of stimulation by social factors (unpublished data). So changes in adrenal weight correlate negatively with the degree of papillary granulation and serum potassium levels. The significance of this relationship, if any, is not apparent.

The rate of potassium repletion, in terms of the disappearance of specific granulation, appears to occur at a constant rate, as indicated by the data in Table 1. Degranulation follows closely a negative exponential curve for each year.

Based on the above evidence it would appear that the development of a relative potassium deficit is a regular feature of hibernation in woodchucks, brought about by continuing losses of potassium without dietary replenishment during the period of dependence on stored fats (*7*).

JOHN J. CHRISTIAN
Penrose Research Laboratory, Zoological Society of Philadelphia, and Department of Pathology, University of Pennsylvania, Philadelphia

References and Notes

1. B. Spargo, *J. Lab. Clin. Med.* **43**, 802 (1954).
2. A. G. H. Pearse and C. R. MacPherson, *J. Pathol. Bacteriol.* **75**, 69 (1958).
3. B. Spargo, F. Straus, F. Fitch, *A.M.A. Arch. Path.* **70**, 599 (1960).
4. R. D. Lillie, *Histopathologic Technic and Practical Histochemistry* (Blakiston, New York, 1954).
5. Measurements of serum potassium were made through the courtesy of Capt. H. C. Sudduth, MC, USN, by the Division of Experimental Medicine, U.S. Naval Medical Research Institute, Bethesda, Md.
6. R. L. Snyder, D. E. Davis, J. J. Christian, *J. Mammal.*, in press.
7. This study was supported by grants H-4836 and H-4759 of the U.S. Public Health Service and by the U.S. Naval Medical Research Institute.

18 April 1961

Existence of Absorption Bands at 730–740 and 750–760 Millimicrons in Algae of Different Divisions

Abstract. Absorption studies, made on suspensions of *Anacystis nidulans, Chlorella pyrenoidosa*, and *Porphyridium cruentum* by means of an integrating spectrophotometer, suggest the existence of pigments absorbing "extreme red" light in the 720- to 800-mμ region. In the blue-green alga *Anacystis*, one pigment of this type exists, which produces a relatively strong absorption band at 750 mμ. In the green alga *Chlorella* and the red alga *Porphyridium*, two considerably weaker absorption bands appear, at 730 to 740 mμ and 750 to 760 mμ, which may be due to one or two pigments. These pigments must be responsible for the photoinhibition of photosynthesis observed in these algae in the same spectral region; as yet, no photoinhibition has been observed in *Anacystis*.

Rabinowitch *et al.* (*1*) and Govindjee *et al.* (*2, 3*) have demonstrated the occurrence of photoinhibition of both photosynthesis and the Hill reaction by extreme red light in various algae. This caused us to make a search for the presence in algal cells of pigments absorbing in the extreme red region of the spectrum. The green alga *Chlorella pyrenoidosa*, the red alga *Porphyridium cruentum*, and the blue-green alga *Anacystis nidulans* were used. *Chlorella* and *Porphyridium* were grown as previously described (see *4*); *Anacystis* is now being grown in our laboratory in the "standard nitrate" medium developed by Emerson and Chalmers for the growing

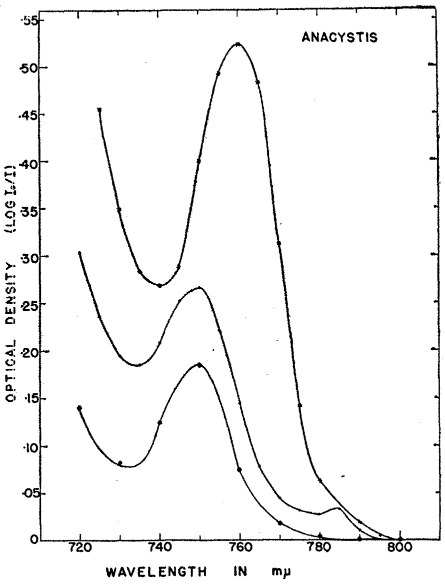

Fig. 1. Absorption spectra of thick suspensions of *Anacystis niduians* showing the occurrence of pigment "P750" in three cultures of different density.

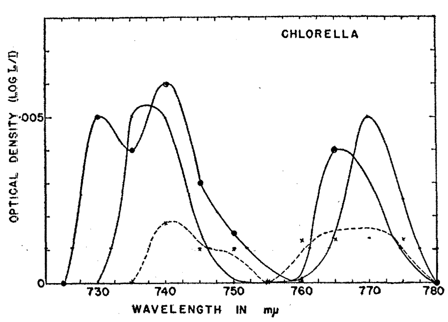

Fig. 2. Absorption spectra of thick suspensions of *Chlorella pyrenoidosa* show the existence of pigments "P740" and "P760" in three different cultures.

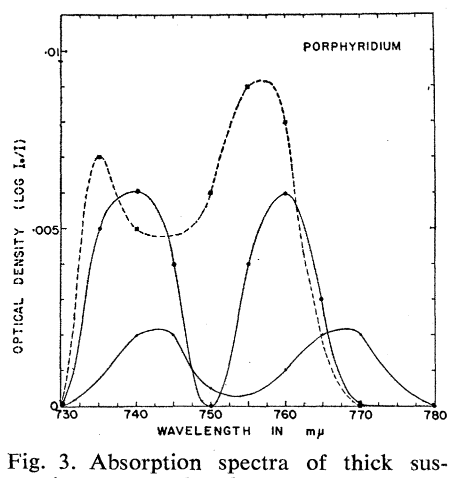

Fig. 3. Absorption spectra of thick suspensions of *Porphyridium cruentum* showing the existence of pigments "P740" and "P760" in three different cultures.

of *Chlorella* (unpublished). We prefer this completely inorganic medium to the citrate-containing medium used by Kratz and Myers (*5*).

The algal cultures were centrifuged and resuspended, either in their culture medium or in an appropriate carbonate-bicarbonate buffer. The bands were first noted as weak but reproducible wiggles on the absorption curves obtained by the usual methods. Because of their weakness, measurements were made on very thick suspensions, with optical densities of about 2.0 at 680 mμ. In making measurements at low optical densities in very concentrated suspensions, both the stability of the instrument and the accuracy with which it can measure true absorption in a strongly scattering suspension are important. Of the instruments available to us, our 12-cell integrating spectrophotometer (*6*) comes closest to satisfying these requirements. Readings were taken at 5-mμ intervals; the half-intensity band width was 2.0 mμ.

Suspensions of *Anacystis* revealed clearly the presence of an absorption peak at 750 mμ (Fig. 1), which has been mentioned earlier (*2*). In some experiments with this alga, the peak was found at 760 mμ; the cause of this difference is unknown. The presence of a 750-mμ pigment ("P750") in *Anacystis* can be detected also with the Beckman DU spectrophotometer. Contrary to what one would expect from the relatively high intensity of this absorption band, *Anacystis* is the one algal species in which no photoinhibition effect could be noted (*2*).

Absorption spectra of several suspensions of *Chlorella* and *Porphyridium* (prepared from different cultures) showed two absorption bands in the extreme red, at 730 to 740 mμ and at 750 to 760 mμ, respectively. Figures 2 and 3, obtained by correcting the experimental absorption curves for a "tail" of the chlorophyll *a* absorption band (assumed to fade out smoothly on the long-wave side), clearly show the two new bands.

We believe that the pigments ("P740 + P760") producing these absorption bands are responsible for the inhibition effect previously detected in photosynthesis and in the Hill reaction of the same algae, since these absorption peaks coincide with the peaks observed in the action spectrum of inhibition (*3*). The weakness of the absorption bands shown in Figs. 2 and 3 suggests that the pigments are either present in very low concentrations or have very low extinction coefficients.

No evidence has yet been obtained of the chemical nature of the new pigments ("P750" and "P740 + P760"). Some experiments suggest, however, that the pigment "P740 + P760" may be similar to the "phytochrome," which Butler *et al.* (*7*) have found in higher plants. Alternatively, the new absorption bands could be due to microcrystals of the chlorophylls, since the latter are known to absorb in the same spectral region (*8, 9*).

GOVINDJEE
CARL CEDERSTRAND
EUGENE RABINOWITCH
Photosynthesis Project,
Departments of Botany and *Biophysics,*
University of Illinois, Urbana

References and Notes

1. E. Rabinowitch, Govindjee, J. B. Thomas, *Science* **132**, 422 (1960).
2. Govindjee, E. Rabinowitch, J. B. Thomas, *Biophys. J.* **1**, 91 (1960).
3. Govindjee, R. Govindjee, J. B. Thomas, E. Rabinowitch, paper presented at the 5th annual meeting of the Biophysical Society (Feb. 1961).
4. Govindjee and E. Rabinowitch, *Biophys. J.* **1**, 73 (1960).
5. W. A. Kratz and J. Myers, *Am. J. Botany* **42**, 282 (1955).
6. C. Cederstrand, in preparation.
7. W. L. Butler, K. H. Norris, H. W. Siegelman, S. B. Hendricks, *Proc. Natl. Acad. Sci. U.S.* **45**, 1703 (1959).
8. E. E. Jacobs, A. S. Holt, E. Rabinowitch, *J. Am. Chem. Soc.* **76**, 142 (1954).
9. We are grateful to J. B. Thomas for his interest in this investigation. Thanks also are due to Rajni Govindjee for her assistance. We take pleasure in acknowledging financial support from the National Science Foundation and the U.S. Public Health Service.

7 March 1961

Air Entrainment in Turbulent Liquids

Abstract. An experimental technique has been developed for measuring the concentration and distribution of air entrained by turbulence in an agitated liquid. The air content was related to the viscosity, surface tension, and turbulence of the liquid by dimensional analysis.

The concentration and distribution of air in turbulent water have been measured by several investigators both by mechanical sampling (*1*) and by electrical methods (*2*) in laboratory channels set at slopes sufficiently steep that when the turbulent boundary layer intersected the free surface there was sufficient transverse kinetic energy to overcome the stabilizing effects of surface tension and air was entrained into the water. The air bubbles were then