the substrate in the reaction mixture, the amount of ethylene formed was 13.6 μl (N.T.P.) after 30 minutes of incubation in the presence of FMN and light. However, there was no formation of ethylene in the presence of FMN in darkness. From the similarity of the structures of ethionine and *S*-ethylcysteine, ethylene from *S*-ethylcysteine might be derived from *S*-ethyl moiety. We conclude that the ethyl moiety of the substrates containing the *S*-ethyl group in their molecular structure is converted to ethylene. We suggested earlier that the acetaldehyde-cysteine complex was a direct precursor of ethylene in apple particles (*3*). We now find that acetaldehyde gives *S*-ethyl moiety after reaction with the SH-compound and that the *S*-ethyl moiety is then converted to ethylene.

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References and Notes

1. K. Shimokawa and Z. Kasai, *Mem. Res. Inst. Food Sci. Kyoto Univ.* **26**, 24 (1965); *Plant Cell Physiol. (Tokyo)* **7**, 1 (1966).
2. ———, *Plant Cell Physiol. (Tokyo)* **8**, 277 (1967).
3. ———, in *Proceedings of the Annual Meeting of the Agricultural Chemical Society of Japan* (1966), p. 17.
4. S. F. Yang, H. S. Ku, H. K. Pratt, *Biochem. Biophys. Res. Commun.* **24**, 739 (1966).
5. *S*-ethyl-L-cysteine and L-ethionine (ethyl-1-^{14}C) were obtained from Mann Research Laboratories and New England Nuclear Corporation, respectively.
6. K. Shimokawa and Z. Kasai, *Radioisotopes (Tokyo)* **14**, 137 (1965).
7. We thank Drs. Kozi Asada and Yasuyuki Yamada for their help in preparing this manuscript.

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Photosynthetic System II: Racial Differentiation in Typha latifolia

Abstract. *The rate of reduction of 2,6-dichlorophenol-indophenol by illuminated chloroplasts isolated from ecological races of* Typha latifolia *was negatively correlated with length of growing season at the site of origin. Efficiency of the photochemical apparatus for this reaction was twice as high in a high-altitude population from Wyoming as in a maritime population from California.*

Although experimental evidence indicates that subspecific populations of plants adapted to different habitats may differ in photosynthetic rates (*1*), and, although Bjorkman *et al.* have detected differences in the photochemical properties of *Solidago vigaurea* populations from shaded and sunny habitats (*2*), there is no evidence available that indicates a relation between macroclimate of origin and basic photochemical properties. I now report experiments that demonstrate higher rates of photoreduction of 2,6-dichlorophenol-indophenol in races from climates characterized by short growing seasons.

Plants from seven populations of broad-leaved cattail (*Typha latifolia* L.), at elevations between sea level and 1980 meters, were obtained from marshes in Oregon, California, Wyoming, and New York. The plants were grown for 2 months under these conditions: day-length, 12 hours; day temperature, 35°C; and night temperature, 25°C. Chloroplasts were isolated (*3*), the concentration of chlorophyll was determined (*4*), and Hill activity was assayed spectrophotometrically (*5*) with 2,6-dichlorophenol-indophenol photoreduction carried out at a light intensity of 27,500 lu/m^2 (2500 ft-c) from a 150-watt incandescent reflector bulb with a water filter. Because of an endogenous rhythm in Hill activity similar to that reported in tomato chloroplasts (*6*), plastids isolated at different times of the day varied considerably in this activity. The data reported represent means of the four highest determinations for each population. Although the rate of the reaction varied throughout the day, the qualitative relation reported here was invariable.

The ability of isolated chloroplasts to reduce 2,6-dichlorophenol-indophenol declined linearly with length of the growing season at the native site (Fig. 1). The regression coefficient (r) was -0.927, which indicates a significant ($.01 > P > .001$) inverse correlation between native climate and photochemical capacity. Reduction of 2,6-dichlorophenol-indophenol is attributed to system II of photosynthesis (*7*). Bjorkman found differences in ability to reduce plastocyanin, a system II–system I mediator, in plants from habitats with different light intensities (*2*). It seems unlikely, however, that the differences reported here could be accounted for solely on the basis of radiation input at the native sites. In fact, the two populations with the longest growing seasons are from sites with quite different radiation inputs; one is from Point Reyes, California, an extremely maritime site with abundant summer fog, while the other is from Red Bluff, California, a site with intense summer sun (*8*). Studies of productivity in cattail marshes at different altitudes suggest greater assimilation rates in populations from high altitudes (*9*). Although Hill activity cannot be equated with productivity, it seems likely that the greater assimilation rates of populations from sites with short growing seasons are at least partially a reflection of photochemical differences of the type documented here and represent a partial compensatory mechanism for the short period favorable for growth.

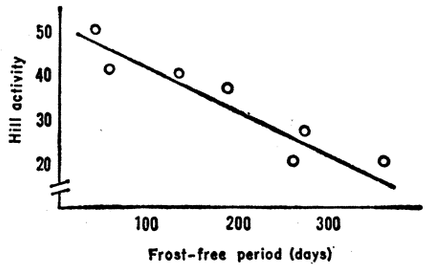

Fig. 1. Relation between Hill activity (micromoles of 2,6-dichlorophenol-indophenol per milligram of chlorophyll per minute) of isolated chloroplasts and the length of frost-free period (in days) at the site of origin of plants from which chloroplasts were isolated.

Preliminary experiments with four populations grown at 17-hour photoperiods with a 12-hour thermoperiod of 25° and 10°C gave an r of -0.952 ($.05 > P > .02$) for the regression of Hill activity on length of frost-free period at the native site.

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References and Notes

1. C. Sorokin, *Nature* **184**, 613 (1959); W. D. Billings, E. E. C. Clebsch, H. A. Mooney, *Science* **133**, 1834 (1961); H. A. Mooney and W. D. Billings, *Ecol. Monogr.* **31**, 1 (1961); O. Bjorkman and P. Holmgren, *Physiol. Plant.* **16**, 889 (1963); P. F. Bourdeau, *Ecology* **44**, 710 (1963); H. A. Mooney and A. W. Johnson, *ibid.* **46**, 721 (1965).
2. O. Bjorkman, D. Fork, W. Urbach, *Carnegie Inst. Wash. Year Book 1964* (1965), p. 416.
3. D. I. Arnon, M. B. Allen, F. R. Whatley, *Biochim. Biophys. Acta* **20**, 449 (1956).
4. D. I. Arnon, *Plant Physiol.* **24**, 1 (1949).
5. A. T. Jagendorf, *Arch. Biochem. Biophys.* **62**, 141 (1956); M. Avron, B. W. Krogman, A. T. Jagendorf, *Biochim. Biophys. Acta* **30**, 144 (1958).
6. J. H. Miller, *Amer. J. Bot.* **47**, 532 (1960); F. M. Hoffman and J. H. Miller, *ibid.* **53**, 543 (1966).
7. J. W. Kinkson and L. P. Vernon, *Plant Physiol.* **34**, 268 (1959); L. P. Vernon and W. S. Zaugg, *J. Biol. Chem.* **235**, 2728 (1960); M. Losada, F. R. Whatley, D. I. Arnon, *Nature* **190**, 606 (1961).
8. E. L. Felton, *California's Many Climates* (Pacific Books, Palo Alto, Calif., 1965).
9. S. J. McNaughton, *Ecol. Monogr.* **36**, 297 (1966).
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