Picea and *Abies*. The R III*b* zone indicates more or less open habitats throughout lowlands. The R III*a* zone began probably about 3000 years ago (*8*), and a boundary between R I (immediately after the cold period) and R II (corresponding to the hypsithermal) is 9740 ± 440 years before 1950 (Y-1130).

Even during the postglacial period, pollen remains of *S. verticillata* were found outside of its present range of distribution. Much more concrete evidence as to the extensive postglacial distribution of the species can be obtained at Yashima-ga-hara bog, which is located about 50 km northeast of the present area of greatest abundance (Fig. 1). As shown in a pollen diagram of *S. verticillata* (Fig. 1), the pollen occurrence ranges from about 0.5 to 5.0 percent of the total arboreal pollen. There is some difficulty in determining whether or not these findings are of airborne pollen transported over the long distance of about 50 km. However, comparisons of the percentages of pollen species from surface samples with percentages of foliage cover in the surrounding forest showed that in all forest areas pollen of distant origin is insignificant compared with local pollen production (*8, 9*). In this case, the continuous occurrence of its pollen indicates the presence of *S. verticillata* in the surrounding area of Yashima-ga-hara bog during this period. It first appeared in the middle of zone R II, and reached its maximum late in zone R III*a*. But in early R III*b* it rapidly decreased, and not even a single grain was found in later stages.

This decrease is associated with fairly recent increases of *Pinus diploxylon* type and nonarboreal pollen, and decreases of climax forest tree pollen which might have been caused by recent human interference (*8, 10*). Human activities have led to large changes in the distributional ranges of many plant species through the destruction of some and the introduction of others. The stratigraphic record of pollen therefore reflects past and present human activities as well as other environmental changes. In particular, the decrease in number and restriction of the distributional range of *S. verticillata* may have been influenced by the usefulness of its wood for building houses. For example, most present-day Japanese families have their own bathtub and other kinds of tubs, most of which are made from the wood of *S. verticillata*. Although the wood is of great practical utility, there is a greater seed sterility and growth of the trees is less rapid in comparison with other conifers. Clearly conservation measures are urgently needed to prevent the eventual extinction of this species, native only in Japan today (*11*).

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References and Notes

1. S. Kokawa, *J. Inst. Polytech. Osaka City Univ. D* **12**, 123 (1961); S. Miki, *ibid.* **8**, 221 (1957); **9**, 125 (1958); J. Nakamura, *Nat. Sci. Rept. Kochi Univ.* **2**, 1 (1952); *Res. Rept. Kochi Univ.* **2**, 1 (1953); J. Nakamura and I. Yamanaka, *Bull. Soc. Ecol.*, **1**, 88 (1951); J. Nakamura and J. Katto, *ibid.* **3**, 15 (1953); *ibid.*, p. 108 (1953); *Ecol. Rev.* **14**, 117 (1955); M. Tsukada, unpublished data.
2. K. Sohma, *Ecol. Rev.* **14**, 121 (1956); *ibid.*, p. 235 (1957); *ibid.*, p. 273 (1958).
3. A. Tai, *Chikyu Kagaku (Earth Sci.)* **64**, 8 (1963).
4. S. Miki, *Successions of Five Native Species in Kiso Based on the Plant Remains* (Nagano Forest Bureau, Nagano, Japan, 1955).
5. Y. Hayashi, *Taxonomical and Phytogeographical Study of Japanese Conifers* (Norin-Shuppan, Tokyo, 1960).
6. J. Nakamura, *Res. Rept. Kochi Univ.* **1**, 1 (1952).
7. In preparation.
8. M. Tsukada, *J. Inst. Polytech., Osaka City Univ. D* **9**, 235 (1958).
9. ———, *ibid.*, p. 217.
10. ———, *Quaternary Res. Japan* **1**, 48 (1958).
11. I thank Prof. E. S. Deevey, Department of Biology, Yale University, for support in the preparation of this paper, Prof. S. Miki, Department of Biology, Osaka City University, for advice, and B. N. Wise for linguistic improvements in the manuscript.

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Dehydration of Seeds in Intact Tomato Fruits

Abstract. *Although the moisture content of the placenta and pericarp of tomato fruits older than 15 days never dropped below about 94 percent, the seeds dehydrated to approximately 50 percent moisture as these organs developed and matured. There was a loss in the total amount, as well as the percentage, of water per seed. Part of this dehydration was mediated by the seeds themselves and part appeared to be due to other portions of the fruit.*

Casual observation would lead one to assume that the seeds in mature fleshy fruits of certain species contain a moisture content considerably below that of the remainder of the fruit. A check of several such species, including watermelon, cucumber, lemon, and tomato, substantiated this. A survey of the literature indicated that although there were numerous reports on the chemical and enzymatic changes during growth of seeds and fruits, little attention had been given to water metabolism during the development of such organs (*1*). A study was therefore undertaken to examine the dehydration of seeds in intact tomato fruits.

Tomato, *Lycopersicon esculentum* Mill. var. Marglobe and Bonny Best, was selected for a detailed examination because this plant could be grown easily in the greenhouse as well as in the garden, thus furnishing a continuous supply of experimental material. It was also found in preliminary experiments that the seeds of tomato fruits showed a more uniform development than did the seeds of other species examined.

The plants were grown under the prevailing conditions in the greenhouses of the Department of Botany, University of Chicago, in fertile soil in 20-cm unglazed pots, or in the garden. Flow-

Table 1. Moisture content of Marglobe tomato seeds from fruits of various ages.

Age (days)	Moisture (%)		Fresh weight per seed (mg)	Dry weight per seed (mg)	Water per seed (mg)
	Fresh basis	Dry basis			
22	90.5	950.0	12.6	1.2	11.4
25	88.5	769.2	11.3	1.3	10.0
27	84.3	538.9	11.5	1.8	9.7
32	80.8	420.0	10.4	2.0	8.4
37	61.0	156.1	10.5	4.1	6.4
41	56.8	131.6	8.8	3.8	5.0
48	50.6	102.5	8.1	4.0	4.1
53	49.3	97.3	7.3	3.7	3.6
59	60.2	140.5	8.9	3.7	5.2

ers were tagged at anthesis and the age of the fruit was determined from that date. Harvested fruits were sectioned with a sharp knife and the seeds were immediately separated from the locular material by gentle pressure with the fingers. Seeds were rapidly blotted free of surface moisture with filter paper and weighed on a Roller-Smith balance. They were then dried to a constant weight at 100°C. In all instances, ten seeds were pooled for weight determinations, and the mean weight per seed was calculated.

Experiments were performed to correlate the water content of various tissues with fruits older than 15 days.

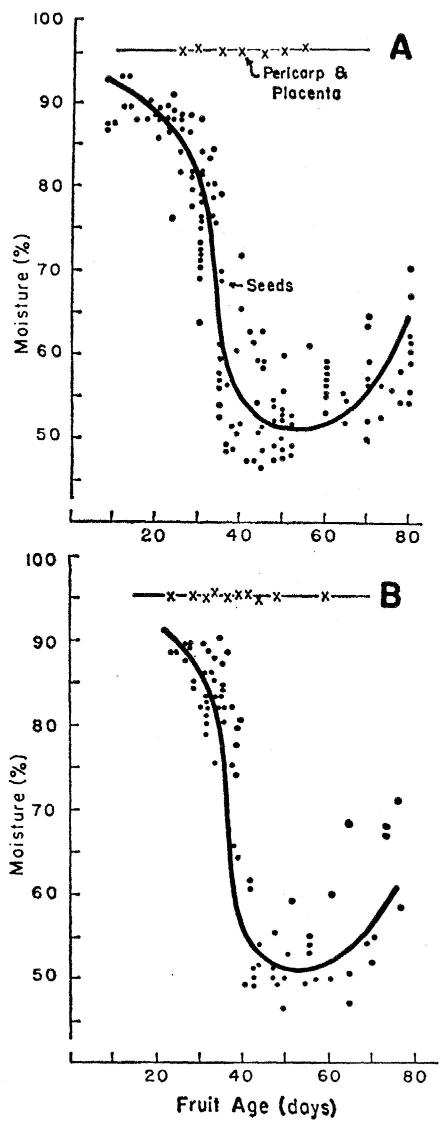

Fig. 1. Percentage moisture (on the basis of fresh weight) of seeds and fruit pericarp and placenta of Marglobe (*A*) and Bonny Best (*B*) tomato fruits of various chronological ages, from plants grown in greenhouses. For a given age, points represent samplings from different fruits.

Results indicated that whereas the percentage moisture of the placenta and pericarp showed little variation with the stage of maturity of the fruit, that of the seeds dropped sharply as the fruits matured (Fig. 1). For tomatoes grown in the greenhouse, this sharp decline in moisture content usually occurred when the fruits were between 25 and 50 days old and varied only slightly with variety or season. The dehydration period of seeds in tomatoes produced late in the growing season in the garden, however, tended to extend over a longer time. The moisture content of the seeds in the fruits always dropped to approximately 50 percent, stabilized at this level for a relatively short period and then the seeds began to reabsorb moisture (Fig. 1).

Since it was conceivable that the observed changes in the percentages of moisture content in the developing seeds merely reflected an accumulation of dry matter, without any change in water content, the total quantities of water in the seeds were also determined (Table 1). These data clearly indicated that although there was an accumulation of dry matter during development, the major factor contributing to the decrease in percentage moisture was an actual loss of water from the seeds.

It was also observed that it was not necessary that the tomato fruits remain attached to the shoot for the seeds to dehydrate. Analyses of the water content of seeds at various intervals subsequent to harvesting and storage of the fruits at 21°C showed that they continued to lose moisture. If the fruits were at the appropriate stage at the time of harvest, a dehydration pattern similar to that observed for fruits developing on the vine was observed. It was also demonstrated that the reduction in percentage moisture of such seeds was not merely a consequence of the accumulation of dry matter. The seeds in detached fruits also began to rehydrate after reaching a moisture content of about 50 percent.

Experiments indicated that mechanisms within the seeds, as well as within the whole fruit, participated in the dehydration system. It was found, for example, that excised seeds with moisture contents in excess of about 80 percent would dehydrate when placed in distilled water. Since in the intact fruit the seeds dry till they have a moisture content of about 50 percent, it would appear that the tissues outside the seed are responsible for a portion of the dehydration. The mechanisms controlling the dehydration of seeds in the highly aqueous environment of the fruit have not been found. The movement of water from seed to fruit against a gradient of moisture concentration shows that an osmotic differential between seed and fruit cannot explain seed dehydration (*2*).

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References and Notes

1. W. Crocker, and Lela V. Barton, *Physiology of Seeds* (Chronica Botanica, Waltham, Mass., 1953); J. P. Nitsch, *Ann. Rev. Plant Physiol.* **4**, 199 (1953).

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Activity Rhythm in *Peromyscus:* Its Influence on Rates of Recovery from Nembutal

Abstract. *Injection of sublethal doses of Nembutal (sodium pentobarbital) into deer mice,* Peromyscus maniculatus rufinus *(Merriam), at different times in their daily activity cycle revealed large differences in rates of recovery. By taking the phase of the circadian rhythm into account, the accuracy obtained in pharmaceutical and physiological bioassays could be increased.*

In recent studies of various circadian rhythms, particular attention has been given to overt locomotor or activity rhythms. These are well exemplified by nocturnal rodents such as *Peromyscus*, which generally become active at a fairly definite time in the evening and remain in this state throughout most of the night. Near dawn these mice cease their activity and do not renew it until the normal time of onset the following evening. Two distinct phases are thus discernible in this type of rhythm, one characterized by more or less continuous activity and the other by a state of rest.

Physiological rhythms of approxi-