occurred in early afternoon. The peak activity in the Hartford area was observed in the late afternoon, and the peak in Massachusetts occurred in the evening. This movement is shown in Fig. 3 where the concentrations, shown for every 2 hours from 1100 to 2100 hours, are plotted at their geographical locations with the values proportional to the diameters of the circles shown. This movement of photochemical activity is consistent with the meteorological data. The wind directions show a clearly defined air flow from southwest to northeast. The average surface wind speeds at Newark Airport and Worcester Airport from 0700 to 2200 hours were 20 and 19 km/hour, respectively. At this speed, transport from the New York area to the Boston area (approximately 300 km) would take 15 hours. However, since surface wind speeds are lower than those aloft as a result of ground friction, the transport time aloft would be less. On 2 July the wind speed aloft (950 mbar and above) at Fort Totten, New York, was 40 to 47 km/hour at 0700 hours and 36 to 43 km/hour at 1900 hours. For speeds in this range the transport time would be approximately 6 to 8 hours. These calculations are thus quite consistent with the movement of a photochemical plume starting in the morning or early afternoon in the New York City area, arriving in Hartford in the late afternoon and in the Boston area in the evening.

Additional demonstrations of the transport mechanism are discussed in detail elsewhere (*9*). In particular it is shown that there is a shift of photochemical activity to later hours of the day with increasing distance from the New York City area. With increasing distance the ozone concentrations are generally higher at night relative to those during the day, daily ozone peak values tend to occur later in the day, and the centers of gravity of ozone diurnal curves tend to show greater dependence on wind direction, shifting to later times of day in northern Connecticut and eastern Massachusetts with southwest winds.

Thus it is clear that primary emissions in the New York City metropolitan area have a substantial effect on ozone concentrations at downwind areas of Connecticut and Massachusetts. The highest ozone concentrations in the region studied are in the Greenwich-Stamford area of Connecticut, 43 km northeast of the center of the New York City metropolitan area, and the next highest are in a region to the east and northeast of Greenwich-Stamford (*1*). Values of the ozone concentration in excess of the federal standard of 0.08 ppm for hourly averages at Fitchburg and Fall River, the two sites with the highest ozone concentrations in Massachusetts (that is, the highest upper quartile of daily maxima), are frequently a result of the transport of photochemical air pollution into Massachusetts. At the Fitchburg site 66 percent of all values of the ozone concentration that are above the federal standard occurred when the wind at Worcester Airport was within 35° of the direction from Fitchburg to the New York City metropolitan region. At the Fall River site the corresponding value is also 66 percent.

On the days with southwest winds and high ozone concentrations in Connecticut, the concentration distribution at the Chester site, which lies to the west of the New York City metropolitan area and thus serves as an indicator of the ozone content of air entering the New York City area, is considerably less than those in Connecticut. However, the Chester site frequently has ozone concentrations above the federal standard. Thus, although the New York City area is substantially adding to the ozone burden of the air entering the region, it is adding to an air mass that is frequently already in excess of the federal standard.

The transport of ozone from urban areas has been discussed in a number of other publications. Cleveland and Kleiner (*10*) have demonstrated transport from the Camden-Philadelphia urban complex at distances up to 49 km. Fankhauser (*11*) has argued ozone transport from four metropolitan areas at distances up to 16 km. High ozone concentrations have been observed in rural Maryland and West Virginia, and the possibility of transport from midwestern cities has been raised (*12*). Ozone transport has been demonstrated to the Mineral King Valley of California (*13*) and out over the Pacific Ocean (*14*). In a general discussion of transport, Martinez (*15*) reports that it has been difficult in the past to substantiate ozone transport from urban areas for distances greater than 75 miles (120 km). In a recent publication Altshuller (*4*) has reported that the Los Angeles ozone plume extends at least 100 miles downwind and conjectures that "if plumes of other cities have similar dimensions, the spacing of cities in the Eastern and Mid-western U.S. is such that the plume of an upwind city could overlap a downwind urban area." The results presented here provide the strongest evidence yet in support of the validity of this conjecture.

W. S. CLEVELAND, B. KLEINER
J. E. MCRAE, J. L. WARNER
Bell Laboratories,
Murray Hill, New Jersey 07574

References and Notes

1. W. S. Cleveland, B. Kleiner, J. E. McRae, R. E. Pasceri, J. L. Warner, paper 75-51.6 presented at the annual meeting of the Air Pollution Control Association, Boston, Mass., 14 June 1975.
2. J. L. Heffter and A. D. Taylor, *Natl. Oceanic Atmos. Admin. Tech. Mem. ERL-ARL-50* (1975).
3. "1972 National Emissions Report" (Publication EPA-450/2-74-012, Environmental Protection Agency, Washington, D.C., 1974).
4. A. P. Altshuller, *J. Air Pollut. Control Assoc.* **25**, 19 (1975).
5. G. C. Tiao, G. E. P. Box, W. J. Hamming, *ibid.*, p. 260.
6. S. M. Bruntz, W. S. Cleveland, B. Kleiner, J. L. Warner, in *Symposium on Atmospheric Diffusion and Air Pollution* (American Meteorological Society, Boston, Mass., 1974), pp. 125–128.
7. W. S. Cleveland and B. Kleiner, *Technometrics* **17**, 447 (1975).
8. J. S. Jacobson and G. D. Salottolo, *Atmos. Environ.* **9**, 321 (1975).
9. W. S. Cleveland, B. Kleiner, J. E. McRae, J. L. Warner, "The analysis of ground-level ozone data from New Jersey, New York, Connecticut, and Massachusetts: Transport from the New York City metropolitan area" (Bell Laboratories technical memorandum, Murray Hill, N.J., 1975).
10. W. S. Cleveland and B. Kleiner, *Environ. Sci. Technol.* **9**, 869 (1975).
11. R. K. Fankhauser, "Ozone levels in the vicinity of 33 cities" (Environmental Protection Agency report, Research Triangle Park, N.C., 1972).
12. W. D. Bach, C. E. Decker, H. L. Hamilton, L. K. Matus, L. A. Ripperton, T. M. Royal, J. J. B. Worth, "Investigation of high ozone concentration in the vicinity of Garnett County, West Virginia" (Report of Project 410-764, Environmental Studies Center, Research Triangle Institute, Research Triangle Park, N.C., 1973).
13. R. P. Miller, M. H. McCutchan, H. P. Milligan, *Atmos. Environ.* **6**, 623 (1972).
14. H. R. Gloria *et al.*, *J. Air Pollut. Control Assoc.* **24**, 645 (1974).
15. E. L. Martinez, paper presented at the conference on Air Quality Measurements sponsored by the Southwest Section of the Air Pollution Control Association, Austin, Texas, 10–11 March 1975.
16. We are greatly indebted to R. E. Pasceri of the New Jersey Department of Environmental Protection for his advice and assistance in carrying out the research reported here and to R. Draxler and J. L. Heffter for their assistance in obtaining the air parcel trajectories.

23 July 1975; revised 3 November 1975

Plant Desiccation: Polysome Loss Not Due to Ribonuclease

Abstract. *During desiccation of the drought-tolerant moss* Tortula ruralis *polysome levels decline substantially before any increase in ribonuclease activity is observed. Furthermore, ribosomes in the desiccated moss are not complexed with messenger RNA fragments. It is concluded that ribosome runoff and failure to re-form an initiation complex mediate polysome loss during desiccation.*

Plant tissues subjected to drought or water stress lose polysomes (*1, 2*). The mechanism underlying this loss is little understood. However, increased activity of ribonuclease observed in tissues under prolonged water stress has been suggested as a potential cause of polysome loss (*3*). This suggestion has been questioned because polysomes can be conserved under certain conditions (for example, in the presence of

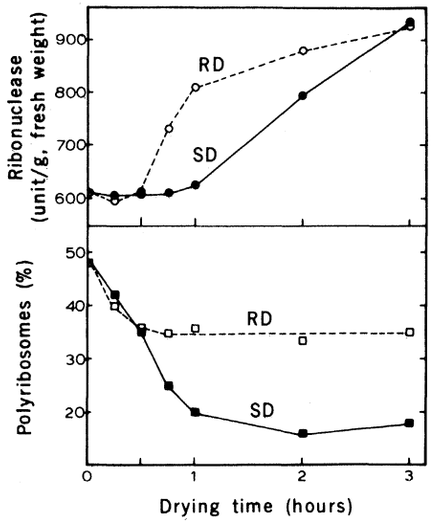

Fig. 1. Decrease in polysomes and increase in ribonuclease activity during desiccation. Undesiccated moss (500 mg) or dried moss (100 mg) was used. Moss was harvested and prepared for experiments as reported earlier (*4*). Rapid drying to 20 percent of the original fresh weight was achieved in 20 minutes by placing the moss on a single layer of cheesecloth, which was in direct contact with silica gel particles in a closed dish. For slow drying, moss was placed over a stirred saturated solution of ammonium nitrate contained in a desiccator (relative humidity, 65 percent). The methods for extracting polysomes and for analyzing their profiles have been described earlier (*7*). Polysome percentages were calculated from density gradient profiles. Ribonuclease activity was assayed as reported elsewhere (*4*). Abbreviations: RD, rapidly dried; SD, slowly dried.

cycloheximide) in water-stressed plant tissues (*2*). Another mechanism of polysome loss has been suggested on the basis of work on the drought-tolerant moss *Tortula ruralis* (*4*). This moss can survive complete desiccation (loss of 80 percent of its original fresh weight), and partial or total loss of polysomes occurs with rapid or slow desiccation, respectively. On rehydration of slowly desiccated moss, protein synthesis is resumed immediately and polysomes appear within a short time (*4*). Since both these processes can also proceed in the presence of actinomycin D, it has been suggested that ribosomes run off from messenger RNA (mRNA) during desiccation and that reassembly of polysomes using the conserved components occurs on rehydration (*4*). We have examined polysome loss during rapid and slow desiccation of *Tortula ruralis* in order to determine the mechanism of this loss.

First, we followed the relationship in time between changes in the ribonuclease activity and polysome level (percentage of total ribosomes) during rapid and slow drying. It is reasonable to expect that if increased ribonuclease activity and decreased polysome level are related as cause and effect, then the former should either precede or coincide with the latter. The results of experiments to determine this are shown in Fig. 1. While ribonuclease activity increased by about 50 percent in both rapidly and slowly dried moss, this increase was detected only after lag periods of at least 30 and 60 minutes, respectively. Polysome levels, however, decreased substantially in as short a time as 15 minutes in both cases. Thus, in both cases ribonuclease activity starts increasing only after the polysomes have declined to their minimum level. Furthermore, while the final ribonuclease activity is the same for both rapidly and slowly dried moss, the final polysome level is much higher in the rapidly dried moss. In the density gradient profiles of polysomes from which the data for Fig. 1 were calculated, no decrease in the number of polysome peaks was observed during rapid desiccation. Thus, the lack of both temporal coincidence and quantitative correlation between the increase in ribonuclease activity and the decrease in polysomes during desiccation shows that ribonuclease is not the primary cause of polysome decrease.

Second, we determined the effect of rapid and slow desiccation on the ability of ribosomes to effect peptide bond formation, as measured by the incorporation of [^{3}H]puromycin into peptidyl-puromycin (*5*). When added in vitro, puromycin will inhibit protein synthesis, but each active ribosome [complexed with mRNA and peptidyl-transfer RNA (tRNA)] will make a peptide bond and the nascent protein (peptidyl-puromycin) will be released (*6*). Fragmentation of polysomes by ribonuclease will produce monosomes still complexed with the mRNA fragment and peptidyl-tRNA and, therefore, still capable of incorporating [^{3}H]puromycin. Runoff of ribosomes from mRNA coupled with failure to re-form an initiation complex will render them incapable of incorporating [^{3}H]puromycin. The ability of ribosomes to incorporate [^{3}H]puromycin in vitro, measured as counts per minute per microgram of ribosomal RNA (rRNA), decreases during rapid and slow desiccation and there is a correlation between incorporation and polysome levels (Table 1). Thus, both polysome level and incorporation are highest in the undesiccated control moss and lowest in slowly dried moss. The results suggest loss of ribosome activity during desiccation. The fate of mRNA during desiccation is an important question, and results of preliminary experiments are consistent with the suggestion that it is conserved, which would be expected on the basis of the results presented here.

Table 1. Polysomes (percentage of total ribosomes) and in vitro ability of ribosomes to form [^{3}H]peptidyl-puromycin in undesiccated (control) and desiccated moss. Moss was dried and polysome levels were determined as described in the legend of Fig. 1. To determine the in vitro formation of [^{3}H]peptidyl-puromycin we used the in vitro protein synthesizing system developed for moss (*8*) with the following modifications. Wheat germ supernatant and amino acid components were excluded from the incubation mixture. Instead, 5 μc of [^{3}H]puromycin (1.3 c/mmole) was added. Incubation was at 37°C and was terminated by adding 0.2 ml of 40 percent trichloroacetic acid (TCA) and 5 ml of 5 percent TCA containing carrier puromycin (50 μg/ml). Precipitate was collected on a Whatman GF/A filter and washed twice with 10 ml of 5 percent TCA containing carrier puromycin (50 μg/ml). The filter was dried and subjected to liquid scintillation counting to determine radioactivity.

Treatment	Polysomes (%)	Formation of [^{3}H]peptidyl-puromycin	
		Total count/min	Count/min per μg rRNA
No desiccation	45	8594	162
Rapid drying	33	3309	78
Slow drying	14	2144	42

In summary, during desiccation (i) there is a decrease in polysomes and an increase in ribonuclease activity which do not coincide in time, the former taking place earlier; (ii) there is a lack of quantitative correlation between the final polysome level and the final ribonuclease activity; and (iii) the ribosomes lose their ability to effect the formation of peptide bonds and are thus, apparently, not complexed with mRNA fragments. On the basis of these results, we suggest that ribosome runoff from mRNA coupled with a failure to re-form an initiation complex is the primary cause of polysome loss during desiccation.

R. S. DHINDSA
J. D. BEWLEY

Department of Biology,
University of Calgary,
Calgary, Alberta, Canada T2N 1N4

References and Notes

1. J. D. Bewley, *J. Exp. Bot.* **23**, 692 (1972).
2. T. C. Hsiao, *Plant Physiol.* **46**, 281 (1970).
3. P. A. Henckel, N. A. Satarova, E. K. Tvorus, *Sov. Plant Physiol.* **14**, 754 (1967); G. W. Todd, in *Water Deficits and Plant Growth*, T. T. Kozlowski, Ed. (Academic Press, New York, 1972), vol. 3, p. 177.
4. E. A. Gwóźdź, J. D. Bewley, E. B. Tucker, *J. Exp. Bot.* **25**, 599 (1974).
5. I. G. Wool and K. Kurihara, *Proc. Natl. Acad. Sci. U.S.A.* **58**, 2401 (1967).
6. D. Nathans and F. Lipmann, *ibid.* **47**, 497 (1961).
7. J. D. Bewley, *Plant Sci. Lett.* **1**, 303 (1973).
8. E. A. Gwóźdź and J. D. Bewley, *Plant Physiol.* **55**, 340 (1975).
9. Supported by National Research Council of Canada grants A6352 and E2250 to J.D.B. and an appropriation from the Environmental Sciences Center (Kananaskis) to R.S.D.

12 September 1975