Comparison of chemical data with weather records of cloudiness at McMurdo Station and our turbidity records gives a faint suggestion that high concentrations of these trace gases were associated with cloudy rather than sunny days. The apparent anticoincidence of the appearance of these gases with sunlight intensity in Antarctica is at variance with their coincidence with sunlight in episodes of urban smog.

Concentrations of these trace gases in Antarctica are surprisingly similar to those reported in Panama (*8*) and are consistent with the lowest continental concentrations reported by Junge *et al.* (*9*) and Johnson (*10*). As expected, they are considerably lower than in a typical urban atmosphere (*11*). Particle counts are also very similar for Antarctica and Panama (Table 2). In fact, the atmosphere of Panama has slightly fewer particles than that of Antarctica in the radius size range between 0.1 and 1.0 μ. However, the total mass loading of atmospheric particulates is some 500 times higher in Panama than in Antarctica, which indicates that the Panamanian atmosphere contains some very large particles. In Panama, most of the particles are sulfuric acid over land areas and ammonium sulfate over ocean areas; this suggests that the ocean is an atmospheric ammonia source and that the land is a sink for the ammonia. This source for ammonia was absent in Antarctica.

The atmosphere of Antarctica is very clean as compared with the industrial atmosphere of the Northern Hemisphere and is similar in that respect to the Arctic. Its similarity (insofar as we have measured it) to the Panamanian atmosphere is surprising, especially since the latter is much more damaging. Man-made materials and objects have been left exposed to the elements in Antarctica for generations with very little deterioration, whereas only short-term exposure to the Panamanian atmosphere results in drastic deterioration.

The differences in deterioration rates between the antarctic and Panamanian atmospheres can probably be explained by a combination of four factors: (i) temperature, (ii) moisture, (iii) nature of the particulates, and (iv) residence time of contaminants. The mean annual temperature in McMurdo Station is somewhat below freezing whereas in Panama it is in the low 20's (centigrade). The atmosphere of Panama contains two to eight times as much moisture as that of Antarctica, and rain, very common in Panama, is rare in Antarctica. Most of the time in Antarctica, therefore, slow, solid-state reactions take place, whereas in Panama much faster reactions of ionic solutions can occur. Corrosion, as measured by corrosion plates exposed to the Panamanian atmosphere, is principally associated with large hygroscopic particles. Furthermore, attacks by bacteria and fungi occur in Panama but not in Antarctica. Sterile nonnutrient agar plates exposed in Panama, either open to the sky or inverted, in a few days show organic growth, thus indicating that both nutrient materials and viable organisms or spores are being deposited. Materials introduced into the Panamanian atmosphere quickly deposit onto surfaces (*12*) which become loaded with contaminants. These four factors indicate that, despite the similarities in the properties measured to date in the Panamanian and antarctic atmospheres, the corrosive effect of the atmospheres can be quite dissimilar. It would thus appear that gaseous components may not be as important in causing atmospheric corrosivity as inorganic and biologic particulates and moisture.

W. H. FISCHER*
J. P. LODGE, JR.
J. B. PATE, R. D. CADLE
National Center for Atmospheric Research, Boulder, Colorado 80302

References and Notes

1. W. H. Fischer, *J. Appl. Meteorol.* **6**, 958 (1967); R. D. Cadle, W. H. Fischer, E. R. Frank, J. P. Lodge, Jr., *J. Atmos. Sci.* **25**, 100 (1968); W. H. Fischer, J. P. Lodge, Jr., A. F. Wartburg, J. B. Pate, *Environ. Sci. Technol.* **2**, 464 (1968).
2. R. A. Bryson, *Weatherwise* **21**, 56 (1968).
3. G. H. Liljequist, *Norwegian-British-Swedish Antarctic Expedition, 1949–52: Scientific Results* (Norsk Polarinstitutt, Oslo, 1956), vol. 2, part 1, pp. 11–15.
4. R. W. Fenn, H. E. Gerber, D. Wasshausen, *J. Atmos. Sci.* **20**, 466 (1963).
5. C. E. Junge, *Air Chemistry and Radioactivity* (Academic Press, New York, 1963).
6. E. R. Frank and J. P. Lodge, Jr., *J. Microscop.* **7**, 449 (1967).
7. J. P. Friend, *Tellus* **18**, 465 (1966).
8. J. P. Lodge, Jr., and J. B. Pate, *Science* **153**, 408 (1966).
9. C. E. Junge, C. W. Changnon, J. E. Mansen, *J. Meteorol.* **18**, 81 (1961).
10. J. C. Johnson, *Physical Meteorology* (Wiley, New York, 1954), p. 354.
11. A. C. Stern, Ed., *Air Pollution* (Academic Press, New York, 1962), vol. 1.
12. O. H. Calderon, R. S. Hutton, E. E. Staffeldt, *Develop. Ind. Microbiol.* **9**, 325 (1968).
13. We thank Miss E. R. Frank for doing the electron morphology work. Portions of the text are reprinted from *Environmental Science and Technology* by permission of the copyright owner, the American Chemical Society, and from *Journal of Atmospheric Sciences* by permission of the American Meteorological Society. The National Center for Atmospheric Research is operated by the University Corporation for Atmospheric Research with sponsorship of the NSF.

* Present address: Ball Brothers Research Corporation, Boulder, Colorado 80302.

27 January 1969

Synodic Month: Variations in the Geologic Past

Abstract. *The value of 31.56 ± 0.74 days for the synodic month in the Upper Cambrian is used together with a maximum in the expected number of days in a synodic month to argue that solar tidal dissipation is important in the dynamics of the earth-moon system and that the moment of inertia of the earth cannot have been much larger then than it is now. The tendency of the measurements to remain near 30 days may be a resonance effect.*

The determinations of the number of solar days in a synodic month at various geologic epochs by Pannella, MacClintock, and Thompson (*1*) offer the possibility of solving for some of the parameters of the earth-moon system. Paleontological data have been used in this manner (*2, 3*).

Because of the tidal dissipative coupling of the earth's rotation to the moon's orbit, both the orbital period of the moon and the rotational period of the earth change. If the dissipation due to the sun's contribution to earth tides is ignored, then the earth-moon system conserves angular momentum. As the earth's rotation slows, the number of (present epoch) hours per day increases, but the moon's orbit gains angular momentum and thus the moon's orbital period increases. Because the synodic month involves both the moon's orbital period and the earth's rotation rate, large changes in the two periods produce a relatively small change in the synodic month. Thus the synodic month is not very sensitive to the earth's rotation rate in the geologic past. In fact, there is a maximum in the number of solar days per synodic month. This must have occurred some time in the past with the earth and the moon in a configuration not too different from that at present. The determination of Pannella *et al.* (*1*) can be used to draw some inferences about the earth-moon system by making use of the length of the synodic month at this maximum.

With the simplest assumptions [the moon's orbit is circular; differences in the moon's orbital plane, the plane of the ecliptic, and the earth's equatorial plane are ignored; there is negligible angular momentum transfer to the earth's orbit or to the moon's rotation, and the like—these seem to be the usual assumptions (*3*)], the maximum is about 31.4 days if the solar tidal dissipation is ignored, and about 32.5 days when

it is taken into account [at about one-fifth of the present lunar dissipation (*3*)]. The observation of 31.56 ± 0.74 days for the Upper Cambrian (*1*) is much easier to explain with solar dissipation included in the dynamics of the earth-moon system.

Runcorn (*3*) suggested that the moment of inertia of the earth has decreased in geologic time—he expects a value of about 4 percent greater at 0.5×10^9 years ago. Such increases are difficult to reconcile with the data of Pannella *et al.* (*1*), in view of the maximum.

The measurements of Pannella *et al.* (*1*) show a tendency to remain at about 30 days. If real, this could be a resonance effect. The 30-day resonance is double; it comes at about 390 days per year, and so is nearly coincident with a resonance of 13 (synodic) months per year. Resonances are treated by Goldreich and Peale (*4*); an extension of their methods is required for this case. Such resonances complicate the dynamics substantially, but will probably not vitiate my arguments here.

RICHARD H. MILLER
Department of Astronomy and Astrophysics, University of Chicago, Chicago, Illinois 60637

References and Notes

1. G. Pannella, C. MacClintock, M. N. Thompson, *Science* **162**, 792 (1968).
2. J. W. Wells, in *The Earth-Moon System*, B. G. Marsden and A. G. W. Cameron, Eds. (Plenum Press, New York, 1966), pp. 70–81; G. J. F. MacDonald, *ibid.*, pp. 165–209.
3. S. K. Runcorn, ibid., pp. 82–92.
4. P. Goldreich and S. J. Peale, *Ann. Rev. Astron. Astrophys.* **6**, 287 (1968).
5. Partially supported by AEC contract AT(11-1)-614.

30 December 1968

Polyoma Virus Gene Activity during Lytic Infection and in Transformed Animal Cells

Abstract. *Randomly labeled RNA's from animal cells either productively infected or transformed by polyoma virus were used to measure virus DNA transcription. During lytic infection, 50 percent of polyoma virus DNA was expressed. In two different polyoma-transformed hamster cell lines, the same 20 percent of the virus genome was transcribed. About 10 percent of polyoma DNA was expressed in the one mouse transformed cell line examined.*

Virus specific RNA's have been detected in animal cells transformed by polyoma, SV40, and several of the adenoviruses (*1–4*). Several reports have compared the virus-specific RNA's found in transformed cells with the RNA's present in cells productively infected with these agents (*3, 5*). In the present study, RNA of known specific activity was prepared from mouse cells undergoing productive infection with polyoma virus. This RNA was used to measure transcription of polyoma virus DNA during the course of lytic infection as well as in cells transformed by this agent.

Polyoma DNA, labeled with C^{14}-thymidine, was prepared from C-57 mouse embryo fibroblasts infected with SE wild-type polyoma virus. Virus was purified by zone sedimentation onto a CsCl cushion followed by two cycles of CsCl equilibrium density centrifugation. Virus DNA was extracted with a mixture of chloroform and isoamyl alcohol (24:1, by volume) in the presence of 1 percent sodium dodecyl sulfate and 1*M* sodium perchlorate (*6, 7*). The specific activity of the C^{14}-DNA was 6100 count min^{-1} μg^{-1}. Double-stranded, twisted, circular DNA (DNA I) was separated from nicked circular (DNA II) and linear DNA's by equilibrium density centrifugation in CsCl containing ethidium bromide (130 μg/ml) (*8*).

Randomly labeled RNA from cells productively infected with polyoma was prepared in the following manner. Monolayers of C-57 mouse embryo cells, growing in 20 Blake bottles in the presence of phosphate-free Eagle's minimal essential medium (MEM) and 2 percent fetal bovine serum, were exposed to carrier-free P^{32}-orthophosphate (10 μc/ml) and allowed to grow to confluency over a 96-hour period. Polyoma virus (SE wild type), previously dialyzed against phosphate-free MEM, was added to the mouse embryo cells at a multiplicity of 15 to 20 infectious units per cell. After a 2-hour adsorption period, infection was allowed to proceed in the presence of the same P^{32}-MEM used during the preceding 96 hours. At 7, 14, 21, 30, and 41 hours after infection, the cells from four Blake bottles were harvested and lysed by 0.35 percent sodium dodecyl sulfate in 0.1*M* NaCl, 0.01*M* sodium acetate (*p*H 5.3) and Bentonite. The preparation was deproteinized with phenol at 60°C, treated with deoxyribonuclease (Worthington Biochemical), 50 μg/ml, and then exposed to Pronase (Calbiochem), 50 μg/ml. After a second phenol extraction, the RNA was applied to a G-100 Sephadex column and the material appearing in the excluded volume was collected. The specific activities of the RNA's isolated from lytically infected cells at the five indicated time periods ranged from 55,000 to 59,000 count min^{-1} μg^{-1}. The RNA's were then pooled to ensure that representatives of all classes of virus-specific RNA transcribed during lytic infection were present in one preparation. This mixture of P^{32}-RNA's will be referred to as "lytic" RNA.

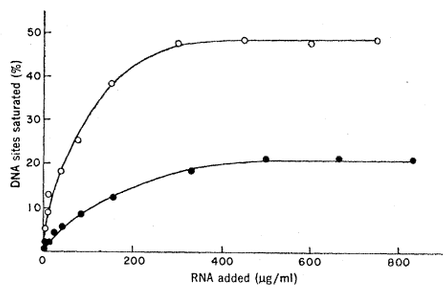

Fig. 1. Saturation of C^{14}-labeled polyoma DNA (6.1×10^3 count min^{-1} μg^{-1}) with P^{32}-labeled lytic RNA (○) (55×10^3 count min^{-1} μg^{-1}) and P^{32}-labeled RNA from the T-54 line of polyoma-transformed hamster cells (●) (88×10^3 count min^{-1} μg^{-1}).

Hamster cells transformed by polyoma virus, derived from a polyoma-induced tumor (T-54), were labeled in tissue culture with P^{32}-orthophosphate (10 μc/ml) for 96 hours. Radioactive RNA from transformed cells was extracted as outlined above. Unlabeled RNA was also prepared from polyoma-induced hamster (T-54) and mouse (1923) tumors. One hamster tumor, induced by a strain of polyoma that replicates relatively efficiently at 30°C (30°C–polyoma tumor) was also a source of unlabeled RNA.

Polyoma virus DNA II, randomly labeled with C^{14}, was immobilized on 50-mm nitrocellulose filters as described by Gillespie and Spiegelman (*9*). Smaller 7-mm filters, containing approximately 0.015 μg of DNA, were punched out of the 50-mm filter and added to a test tube (10 by 25 mm) containing 0.8*M* NaCl, 0.002*M* TES [*N*-tris(hydroxymethyl)methyl-2-amino-