ber of precautions for early moon missiles. The gettering action of such a porous reactive surface may also be important in the final disappearance of any original lunar atmosphere.

Meanwhile, there are several laboratory experiments that would throw light on these questions. It would be worthwhile to study the changes in the reflectivities and other surface properties of common rocks and of carbon-, nitrogen-, and oxygen-containing compounds when exposed to high-energy particle radiation, ultraviolet radiation, and heating cycles. Such studies would have to be made under the most stringent vacuum conditions to avoid disturbances from oxygen-recombination effects. A comparison of the results with various lunar reflectivities might then make possible the closer identification of lunar rock species (*5–7*).

JOHN R. PLATT

Department of Physics,
University of Chicago, Chicago, Illinois

References

1. B. Donn, *Mém. soc. roy. sci. Liège, sér.* 4, 15, 571 (1954).
2. B. Donn and H. C. Urey, *Astrophys. J.* 123, 339 (1956).
3. J. R. Platt, *ibid.* 123, 486 (1956).
4. T. Gold, *Monthly Notices Roy. Astron. Soc.* 115, 585 (1955).
5. I am indebted to J. Lederberg and D. B. Cowie (*6*) and to H. C. Urey (*7*) for letting me see their manuscripts on related subjects in advance of publication.
6. J. Lederberg and D. B. Cowie, *Science* 127, 1473 (1958).
7. H. C. Urey, "On the composition of the lunar surface," in preparation.

6 May 1958

Functional and Structural Observations on Chronically Reserpinized Monkeys

The effects of reserpine on the behavior of monkeys and chimpanzees were noted as reversible phenomena, resembling those encountered in human Parkinsonism—namely, hypokinesia, lethargy, mask-like face, muscular rigidity with "cogwheel" quality, sialorrhea, and tremors at rest (*1*). Even though experimental animals recovered completely from any ill effects shortly after the interruption of reserpine medication, and although no anatomical changes have hitherto been reported, it would be surprising if the profound neurological aberrations that occur in the course of prolonged medication had no anatomical counterparts in the central nervous tissue. The clinicoanatomical study described in this report was carried out on two adolescent female African green monkeys kept under reserpine (*2*) medication for 18 months and one male monkey given reserpine for 2 days and kept for 2 years without any drugs.

The first female received 0.5 mg of reserpine per kilogram of body weight intramuscularly daily for 238 days. Spontaneous activities lessened (*3*). Tremors at rest were frequently observed about 4 hours after each daily dose, lasting for several hours. Increasing the dosage to 0.75 mg/kg led to the appearance of some muscular rigidity. Reserpine administration was discontinued for 14 days. During the first 4 days of this interval the monkey still exhibited tremors at rest; during this entire period spontaneous activity remained less than it had been prior to the experiment. Administration of the drug was then resumed, at dosages of 0.2 to 0.4 mg/kg daily for 160 days. Tremors reappeared on the second day, becoming almost continuous and quite violent toward the end of this period. Treatment was again interrupted for 5 days, during which time the tremors disappeared but the activity level remained low. Treatment with reserpine was resumed at a dosage of 0.4 mg/kg; the dosage was gradually increased to 0.8 mg/kg and continued at this level until the experiment was terminated, after a total of 615 days. During this last period of treatment the animal developed what amounted to "status tremoris."

The second female was given reserpine daily for 512 days. Doses larger than 0.6 mg/kg led to some rigidity and hypokinesia (*3*). Doses as low as 0.3 mg/kg maintained the animal in a state of reduced activity and almost continuous tremor at rest. The drug was withheld for 5 days and then the animal appeared normal, with no tremors. Treatment was resumed at a dosage of 0.6 mg/kg; dosage was increased to 0.7 mg/kg and continued at this level until the experiment was terminated, after a total of 552 days.

The three animals were killed by the perfusion fixation method (*4*). Postmortem examinations revealed no gross abnormalities of visceral organs, brains, or spinal cords.

Microscopic examination revealed normal histological and cellular structures in the central nervous system of the monkey that was given no reserpine for 2 years.

The brains and spinal cords of the two chronically reserpinized monkeys showed no signs of hemorrhages, infarcts, softening, demyelination, glial reaction such as gliosis, or activation of histiocytes with phagocytosis. The cerebellum was notably free of any indication of change, all elements being well preserved and well stained.

Neuronal differences between the two chronically treated animals and the one which had had no drug for 2 years were clearly evident in some parts of the brain, especially in the cerebral cortex, basal ganglia, and brain stem. Conspicuous cytological changes involved the neuronal nucleus and nucleolus. A considerable number of the nuclei were markedly enlarged and pale. The pallor of the nuclei was caused by what appeared as a hole in the karyoplasm. These holes varied in size, and each had a scalloped periphery, as though some substance had been removed in the histological preparation. The nucleolus was located in the karyoplasm and stained lightly with gallocyanin at *p*H 1.7. The chromaphil bodies adherent to the nucleolus were slightly smaller in the two reserpinized monkeys than in the animal that had been given no drug for 2 years. Considerable variation from cell to cell and in different regions of the brain was observed.

The fact that neither severe changes nor loss of neurons was observed suggests reversibility of the process. However, the significance of these observations is as yet not known. In man, somewhat similar nuclear changes have been reported in insulin shock (*5*), anoxia (*6*), and so on. These have been ascribed to a process of vacuolization of the nucleolus (*7*). In the study discussed in this report, no vacuolization of the nucleolus was demonstrated. In keeping with the current concepts that nuclear-nucleolar activities are involved in protein metabolism of neurons (*8*), the results given here indicate that during chronic reserpine medication, cell metabolism is influenced at all levels of the nervous system. Furthermore, this cellular response is not specific to the monkey; we have identified similar nuclear changes throughout the brains of cats subjected to powerful reserpine treatment. The ubiquitous effect on the nervous system is consistent with the wide range of symptoms which these animals exhibit, but we would hesitate to correlate this morphological alteration with any specific symptom. Although many of the cerebral neurons were involved, we observed no marked changes in temperament and "personality." Whether the changes represent a primary effect of reserpine on neurons or a secondary effect through other systems cannot be settled on the basis of the present morphological observations. It is noteworthy that the neuronal changes did not appear predominantly in the brain stem and basal ganglia, in contrast to the pathological changes in *paralysis agitans* and postencephalitic Parkinsonism.

WILLIAM F. WINDLE
JAN CAMMERMEYER

Laboratory of Neuroanatomical
Sciences, National Institute of
Neurological Diseases and Blindness,
National Institutes of Health,
Bethesda, Maryland

References and Notes

1. W. F. Windle *et al.*, *Am. J. Physiol.* 183, 674 (1955); ———, *Federation Proc.* 15, 202 (1956); ———, *Anat. Record* 124, 474 (1956); J. Joralemon and W. F. Windle, *ibid.* 127, 493 (1957); W. F. Windle *et al.*, *Trans. Am. Neurol. Assoc.* 81 (1956), 69 (1957); E. R.

Feringa and W. F. Windle, *Excerpta Med.* Sect. VIII 10, 104 (1957).
2. A preparation (Rau-sed) produced by E. R. Squibb & Sons was employed.
3. A motion picture film of the experimental animals is available from this laboratory on a loan basis.
4. H. Koenig, R. A. Groat, W. F. Windle, *Stain Technol.* 20, 13 (1945).
5. F. Kobler, *Arch. Psychiat. Nervenkrankh.* 107, 688 (1938).
6. J. Pichotka, *Beitr. pathol. Anat. u. allgem. Pathol.* 107, 117 (1942).
7. W. Höpker, *Acta Neuroveget.* (*Vienna*) 15, 14 (1957).
8. L. Einarson, *Am. J. Anat.* 53, 141 (1933); H. Hydén, *Acta Physiol. Scand. Suppl. 17,* 6, 1 (1943).

3 February 1958

Turbidity Currents and Displaced Fresh-Water Diatoms

Kolbe (*1, 2*) called attention to an abundance of displaced fresh-water diatoms in deep-sea cores of the eastern Atlantic Ocean. He considered three possible theories to explain this distribution of such out-of-place floras. The theories considered are: potamic or ocean-current theory, aeolian theory, and Atlantis theory (modified from Malaise, *3*). The first two are tenable, and we feel that an additional possible method of distribution of the forms should also have been considered, that of distribution by turbidity currents.

Evidence of oceanic turbidity currents has been presented by Heezen and Ewing (*4*), Erickson, Ewing, and Heezen (*5*), Kuenen (*6*), and many others. Perhaps among the better documented ones is the movement associated with the Grand Banks earthquake, described by Heezen and Ewing (*4*). Other evidence has been pointed out by Andrée (*7*), who noted that Atlantic submarine cables are most frequently broken during the rainy seasons along the African and South American coasts. This would support the inference that sediments move along the ocean bottom in turbidity-current or slump fashion.

Several examples of displaced foraminiferal faunas appear in geologic literature. Phleger (*8*) described a displaced fauna from a deep-sea core consisting of shallow-water foraminifera and, lower in the core, sand containing twigs, nuts, and bark fragments of dicotyledonous bushes and trees. Phleger (*9*) concluded that "Deep-sea sands, having only shallow-water species, are believed to have moved down as a unit without contaminating other sediments," thus inferring movement by turbidity currents. Natland (*10*) concluded that turbidity currents are of considerable importance in distribution of microfossils.

Turbidity currents are considered to be common features of the continental slopes and of all other major submarine slopes. Evidence of them in the area described by Kolbe (*1, 2*) can be found in deep-sea cores. An interesting deep core taken from the Romanche Deep shows interbedded sand of angular fragments of mafic rocks, clay, and silt, with occasional streaks rich in organic remains (Pettersson, *11*). The lower part of the core consists of calcareous ooze. Recently published photographs (*12*) of the floor of the Romanche Deep show the coarse texture of particles at the surface. Pettersson (*11*) concludes that the general area is tectonically active, supplying brecciated rock fragments to slumps which moved down the steep slope into the Romanche Deep. Core No. 238, mentioned by Kolbe (*1, 2*), occurs in the deep and contains an abundance of displaced diatoms.

Diatomaceous cores studied by Kolbe (*1, 2*) fall into two categories or areas—those east of the Mid-Atlantic Ridge, in which diatoms were common in many horizons, and those west of the ridge, in which diatoms occur only at individual horizons and even there are relatively uncommon. Core No. 246 is practically at the crest of the ridge and contains *Melosira granulata* at a single horizon. Although this form is by far the most abundant one in cores east of the ridge, it does not occur west of the ridge, as reported in Kolbe's tabulation (*2*). Fresh-water species do occur in cores on the ridge and in cores No. 255 and 267 west of the ridge. Floras of the last two localities have nothing in common with those east of the ridge, according to Kolbe's tabulation (*2*), and certainly seem to have been derived from a different source. Generalizations that suggest a single source and homogeneity of the flora seem unwarranted.

A distribution other than by oceanic currents is suggested for these fresh-water forms in view of the above distribution. Lohman (*13*) concluded that the settling time of diatoms through three miles of sea water must be measured in hundreds of years. It would thus seem improbable that a current of moderate velocity, such as the equatorial Atlantic currents, could selectively distribute the fresh-water diatoms in the pattern documented by Kolbe (*2*). A more localized phenomenon is suggested, one in which the diatoms were probably part of the flocculent of fine sediments which forms at the mouths of most major streams as they enter the sea, a flocculent which then moved downslope with the entrapped diatom flora without contamination by contemporary marine forms and without contamination of the normal oceanic currents.

If the displaced diatoms were brought into the area of the Cape Verde basin either by wind of the Harmattan haze or by oceanic currents, distribution of diatoms through thick sequences of sediments would be expected to be more constant than Kolbe infers. The relatively slow rate of sedimentation and the near constancy of wind and oceanic currents over hundreds of years would tend to produce a constant or nearly constant supply of organic material through time. On the other hand, turbidity currents can disrupt the average rate of sedimentation and can deposit relatively thick layers of near-shore material into the deeps at irregular intervals. It would thus be possible to deposit nearly pure, near-shore displaced faunal and floral elements in thick layers in deep water in a very short time. Because of this marked variation in assumed depositional rate, it seems unlikely that rate of sedimentation is a reliable means of telling geologic ages, even back to the Tertiary.

Turbidity currents might explain the concentrated occurrence of diatoms in the cores mentioned by Kolbe (*1*) (Nos. 229, 230, 234, 235, and 238), for all these cores occur in deeps east of the Mid-Atlantic Ridge or on the continental slope west of Africa.

J. KEITH RIGBY
LLOYD H. BURCKLE
Department of Geology,
Brigham Young University,
Provo, Utah

References and Notes

1. R. W. Kolbe, *Science* 126, 1053 (1957).
2. ———, "Diatoms from equatorial Atlantic cores," in *Report of the Swedish Deep-Sea Expedition* (Göteborg, 1955), vol. 7, fasc. III.
3. R. Malaise, *Sjunket land i Atlanten* (Ymer, Stockholm, 1956).
4. B. Heezen and M. Ewing, *Am. J. Sci.* 250, 849 (1952).
5. D. B. Ericson, M. Ewing, B. Heezen, *Bull. Am. Assoc. Petrol. Geologists* 36, 489 (1952).
6. P. H. Kuenen, *Marine Geology* (Wiley, New York, 1950); *Am. J. Sci.* 250, 874 (1952).
7. K. Andrée, *Geologie des Meeresbodens* (Borntrager, Leipzig, Germany, 1920), vol. 2.
8. F. B. Phleger, F. L. Parker, J. F. Peirson, "North Atlantic foraminifera," in *Report of the Swedish Deep-Sea Expedition* (Göteborg, 1953), fasc. II.
9. F. B. Phleger, "Displaced foraminiferal faunas," *Soc. Econ. Paleontol. Mineral. Spec. Publ. No. 2* (1951).
10. M. L. Natland, "Treatise on Marine Ecology and Paleoecology," *Geol. Soc. Am. Mem. No. 67* (1957).
11. H. Pettersson, *The Ocean Floor* (Yale Univ. Press, New Haven, Conn., 1954), p. 94.
12. J.-Y Cousteau, *Natl. Geograph. Mag.* 113, 373 (1958).
13. K. E. Lohman, "Geology and Biology of North Atlantic Deep-Sea Cores Between Newfoundland and Ireland," *U.S. Geol. Survey Profess. Paper No. 196* (1942), pt. 3.

17 April 1958

Rigby and Burckle do not believe in my suggestion No. 3 (*1*) based on Malaise's theory (fresh-water diatoms found in deep-sea sediments of the Atlantic but originating in a fresh-water biotype, which subsequently became submerged) and ascribe the layers of these diatoms, as in core No. 234, to the action of turbidity currents.

Rigby and Burckle suggest that fresh-