Livingstone's statement that evidence of pole shift from paleomagnetic studies "is not pertinent unless it can be shown that the magnetic and mechanical poles shift together" ignores the basis of all modern theories of the origin of the earth's magnetic field (*4*).

M. Ewing
Lamont Geological Observatory, Columbia University, Palisades, New York

W. L. Donn
Department of Geology, Brooklyn College, Brooklyn, New York

References and Notes

1. *Glacial Map of Canada* (Geological Association of Canada, Toronto, 1958).
2. R. F. Flint, *Glacial and Pleistocene Geology* (Wiley, New York, 1957), p. 315.
3. J. K. Charlesworth, *The Quaternary Era* (Arnold, London, 1957), vol. 2, p. 1321.
4. This report is Lamont Geological Observatory Contribution No. 331. *Erratum*: In part II of our theory [*Science* 127, 1159 (1958)], line 13 of the section "Pluvial Stages" (p. 1161) should have read: " . . . and the desert(s) of Central Asia and Australia, the (African) Kalahari, . . ."

3 November 1958

Uranyl-Ion Exchange Resin Reaction and Demineralization

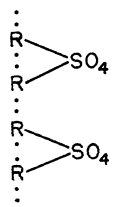
Abstract. Complex ion formation on an ion exchange resin with one ion of an electrolyte results in the release of exchange sites which are then available for the sorption of the remaining ion. The result is a demineralization with but one ion exchange resin. The exchange capacity of the resin is limited by the nature of the complex formed.

Complex ion formation directly at the exchange sites of an ion-exchange resin in a specific form is common (*1*). Thus, an anionic ion-exchange resin in the sulfate form will add on uranyl ions in the formation of a uranyl sulfate complex, $[UO_2(SO_4)_n]^{2-2n}$, a representative type being $[UO_2(SO_4)_2]^{--}$(*2*). If R represents an exchange site of an anionic ion-exchange resin—for example, IRA-400 or Nalcite SAR—this reaction may be formulated as

$$R(SO_4) + UO_2^{2+} \rightarrow R[UO_2(SO_4)_2]^{--}$$

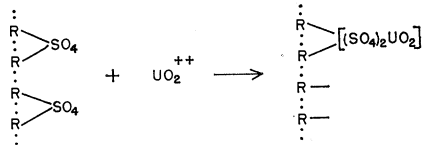
The uranyl sulfate complex, like the SO_4^{--}, is doubly negatively charged and so remains sorbed by the anionic resin.

Such complex ion formation has implications in water demineralization. The sulfate form of an anionic ion exchange resin may be represented as follows:

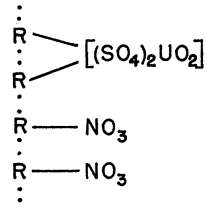


where · · R · · R · · indicates a portion of the ion-exchange resin matrix and the sulfate radicals are shown attached to the active centers throughout the resin.

If this resin is treated with a solution of uranyl nitrate, for example, reaction of the uranyl ions to form the uranyl sulfate complex may proceed thus:



This results in the release of two exchange sites in the resin matrix. These are now available for the sorption of the nitrate ions of the uranyl nitrate, resulting in



Whatever the specific formula of the uranyl sulfate complex may be, two exchange sites will always be left after complexing to sorb the nitrate ion or other anion of the initial uranyl compound. Thus, a demineralization has been accomplished with only a single ion-exchange resin of the anionic type.

Five grams (dry weight) of IRA-400(SO_4), with a total exchange capacity of 15 milliequivalents (meq) were shaken with 30 ml of 1-percent uranyl nitrate solution, 10.0 g of $UO_2(NO_3)_2 \cdot 6\ H_2O$ per liter. This solution is 0.040N in uranyl ion; 30 ml of it would contain 1.2 meq or approximately 8 percent of the total ion-exchange resin capacity. After shaking with the resin, the supernatant solution was filtered. Separate portions of the filtrate were tested for uranyl ion by the addition of 0.25M potassium ferrocyanide, and for nitrate ion, by the addition of $FeSO_4$ and concentrated H_2SO_4 (brown ring test). Both tests were negative, indicating that the sulfate form of the IRA-400 resin had sorbed both the positive uranyl ion and the negative sulfate ion.

Upon the assumption that the ion $[UO_2(SO_4)_2]^{--}$ is formed, only half the total ion-exchange resin capacity is available for sorption of uranyl ions. The other half is used in sorbing the nitrate ions. If the uranyl ion were to form a complex ion $[UO_2(SO_4)_3]^{4-}$, only one-third the total resin exchange capacity would be available for the sorption of uranyl ions. For the formation of an ion $[UO_2(SO_4)_n]^{2-2n}$, the fraction of the resin exchange capacity available for uranyl ion sorption would be $1/n$.

With a complex ion of the type $[M_a(X)_b]^{az_1-bz_2}$, where the valence of the metal M is z_1 and that of the nonmetal X is z_2, the fraction of the ion-exchange resin capacity available for the sorption of the metallic ion, in terms of equivalents, is az_1/bz_2.

Walter E. Miller
Department of Chemistry, City College, New York

References and Notes

1. W. E. Miller, *Anal. Chem.* 29, 1891 (1957).
2. T. V. Arden and G. A. Wood, *J. Chem. Soc.* 1956, 1596 (1956); R. Kunin and A. F. Preuss, *Ind. Eng. Chem.* 48, 30A (1956).

22 August 1958

Histology of Mammoth Bone

Abstract. Compact bone from a frozen Alaskan mammoth was examined histologically and chemically to determine whether there had been any detectable alterations since the death of the animal. Histological sections closely resembled similar specimens from modern elephants. Total nitrogen and acid-extractable carbonate were at levels to be expected in fresh bone.

For the chemical investigation of archeological bone, a control is usually provided in the form of a fresh animal, or human, bone. A possible substitute worth considering would be bone which is old but which, nevertheless, has not undergone appreciable alteration. For this purpose it is desirable to investigate the characteristics of "glacier-preserved" bone, since in this case there has, presumably, been little if any organic decomposition or interchange of substance between the bone and the surrounding environmental matrix.

The American Museum of Natural History in New York kindly supplied us with a fragment of compact bone from the mammoth skeleton discovered in 1907 at Elephant Point in Eschscholtz Bay, Alaska, by L. S. Quackenbush. Quackenbush made it very clear that the mammoth was embedded not in masses of pure ice, but in frozen silt distributed between ice layers in so-called "ice cliffs" (*1*). The explanation offered by Quackenbush for the fine preservation of hair, wool, tendons, and even some of the soft tissues is that a flood-plain sediment was frozen soon after burial of the mammoth and remained at a mean temperature below 28°F, thus causing the deposit to become progressively and permanently solidified. Quackenbush refers the remains of this particular mammoth to the Pleistocene period. A minimum of several thousand years since the bones were deposited must be conceded.

The fragment, roughly, 4 by 2 by 2

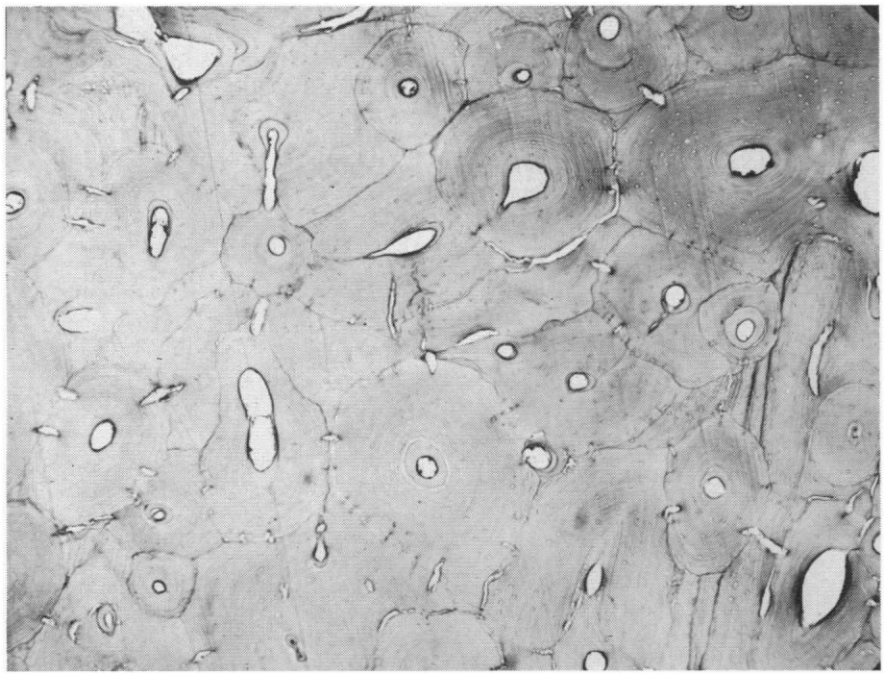


Fig. 1. Cross section of compact mammoth bone, decalcified and stained with hematoxylin and eosin. (× about 47)

in. in size, was a piece from a long bone —femur, tibia, or the like. On exposure of the marrow cavity, the spongy tissue was found to be infiltrated with dirt, hair, and a few small pebbles. The outer surface resembled fresh bone in that it was smooth and shiny. It had the characteristic odor of fresh bone but was yellowish brown in color.

Longitudinal and transverse slices of the specimen, about 3 mm thick, were decalcified, cut at 17 μ, and stained with hematoxylin and eosin (Fig. 1). By comparing our sections with Amprino's picture and description (*2*) of fresh elephant bone, we were able to identify our specimen conclusively as belonging to the genus *Elephas*. The fiber bundles are relatively thin and in orderly disposition. The vascular canals are transversely situated, as in the femur and humerus of the elephant. The fragment is probably from the more central portion of the diaphysis —that is, it is well removed from the epiphyseal plates, as indicated by the osteons of different sizes and shapes. From the descriptions of Amprino we were able to conclude that the fragment is from an immature adult.

The routine histology of the sections thus confirmed our initial observation that the fragment had all the appearances of a fresh bone. No foreign material was observed in the sections. There was no evidence of loss by leaching, and the typical bone pattern was remarkably intact. These facts support the hypothesis that glacier preservation constitutes as inert an environment for biological material as can be found under natural conditions (*3*).

As a further check on the condition of the mammoth bone, we analyzed the bone for total nitrogen and acid-extractable carbonate. The mean value for nitrogen, by the Kjeldahl method, was 4.2 percent by weight; for the carbonate, 3.4 percent carbon dioxide. These values fall definitely within the range to be expected in fresh, compact mammalian bone.

H. C. Ezra
S. F. Cook

Department of Physiology, University of California, Berkeley

References

1. L. S. Quackenbush, *Bull. Am. Museum Nat. Hist.* **26**, 87 (1909).
2. R. Amprino and G. Godina, *Pontif. Acad. Sci. Commentationes* 11, No. 9 (1947).
3. R. F. Heizer and S. F. Cook, *Univ. Calif. (Berkeley) Publs. Anthropol. Records* **12**, No. 2 (1949).

15 December 1958

Aggregate Replication, a Factor in the Growth of Cancer

Abstract. Microscopically, most clinical carcinomas appear as aggregates of neoplastic cells in a matrix of connective tissue. As the tumor grows, increasing numbers of nests of cells are seen. Studies in which matrix tissue culture techniques are used implicate factors intrinsic to the aggregate in the continuing propagation of new nests of cells.

The growth of cancer is commonly measured in terms of an increase in the number of various structural units. The cell is traditionally the primary unit of interest. Improved techniques of optical and biochemical resolution have recently provided opportunities for considering replication of subcellular structures down to the size of large molecules. Another kind of structural unit commonly occurring in cancer is the nest or aggregate of cancer cells. Most carcinomas are made up of such nests of tumor cells scattered in the connective tissue of the host. Microscopically this feature is seen most clearly with low magnifications of about 100.

As the cancer grows, increasing numbers of nests of cells are seen. Similar aggregates are usually seen in local and distant metastases. Although the appearance of these aggregates of cells is used in the histogenic classification of tumors, aggregate multiplication as a quality in the growth of cancer appears to have gone unnoticed until very recently (*1*). Inadequacy of techniques and an absence of suitable experimental material may have been mainly responsible for this apparent oversight.

The general problem of aggregate replication has been studied in this laboratory during the past year, primarily from the point of view of this phenomenon as a factor in the spread of cancer. To provide a workable approach, the question "How does cancer spread?" has been rephrased so that it reads "How do groups of cancer cells multiply?" For convenience in initiating our study, we contrived an oversimplification, involving the idea of intrinsic and extrinsic factors in aggregate replication. Is the capacity to form new groups of cells contained within preexisting groups of tumor cells so that aggregate replication proceeds without the intervention of stromal tissue (intrinsic factors)? Do stromal cells participate in the replication of nests of tumor cells (extrinsic factors)?

This is a preliminary report describing some of our observations on the intrinsic capacity of nests of neoplastic cells to form new nests (*2*). We have found that the cultivation of continuous lines of human cells with matrix tissue culture techniques provides a convenient way to examine this phenomenon.

The sponge matrix tissue culture method is as follows. For a dense inoculum, a slice of cellulose sponge is wiped over the wall of a stock tube containing cells, or a particle of Gelfoam bearing cells is placed on a slice of cellulose sponge. The sponge is then cemented to the wall of a tube with a clotting mixture consisting of one drop of chick plasma and two drops of 20-percent chick embryo extract. Dilute suspensions of cells are prepared directly in the clotting mixture.The cells are suspended in the embryo extract just before preparation of the coagulum, or are