of particles in residence around the spacecraft.

In the previous consideration we did not discuss the problem of dark adaption. The dark-adapted eye becomes approximately 10^4 times more sensitive. Dark-adaption effects will be important in the range below about 10^{-11} to 10^{-12} ssb. If the spacecraft corona can be reduced to this order of brightness (requiring discharge rates of less than ounces per day), then considerations of dark adaption will become important.

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4. We express our appreciation for the effective performance of the S-1 experiment by astronauts C. Conrad and G. Cooper and acknowledge helpful conversations with many of the astronauts and with L. Dunkelman and R. Tousey.

6 June 1966

Radiocarbon Dating of Coastal Peat, Barrow, Alaska

Abstract. *A buried, frozen section of peat from sea level yielded radiocarbon dates between 700 and 2600 B.C.; it suggests burial by a transgressing sea.*

Recent studies at Barrow, Alaska, help to enlighten the late-Pleistocene and Recent history of the arctic coastal plain of Alaska (*1*). During the last 10,000 years the tundra landscape has been modified by cryopedological processes and thaw-lake migration; coastal shorelines have been altered by erosion and fluctuating sea levels. Radiocarbon dates from the Barrow spit indicate that the highest ridges formed, at sea levels slightly above the present datum, between A.D. 250 and 1100; archeological dating of the Birnirk settlement suggests occupancy during a period of a lower sea level within this interval (*2*). We now report three radiocarbon dates, from a nearby buried peat section, between 700 and 2600 B.C.; they predate formation of the northern extension of the spit (Fig. 1).

In October 1963 a severe storm, with a wave surge 3 to 4 m above normal sea level, breached the spit in three places (*3*). As a result, masses of peat were exposed at and slightly below sea level in the area indicated in Fig. 1. The existence of this massive buried peat had been known from the early days of construction at Barrow when canals were seasonally dredged through the spit for access to the lagoons (*4*). Several pits dug by us on the existing islands uncovered a continuous frozen peat section extending to a depth of 1.5 m below sea level; it contained small amounts of interbedded coarse sands in the upper section. The peat, where still buried, is perennially frozen and has high contents of salt and ice. The upper, mid, and basal 25-cm-long portions of a 1.5-m-long core yielded, by radiocarbon dating, ages of 2650 ± 160 (I-1868), 2860 ± 140 (I-1949), and 4570 ± 130 (I-1869) years, respectively. Botanical composition was of freshwater vegetation—principally mosses.

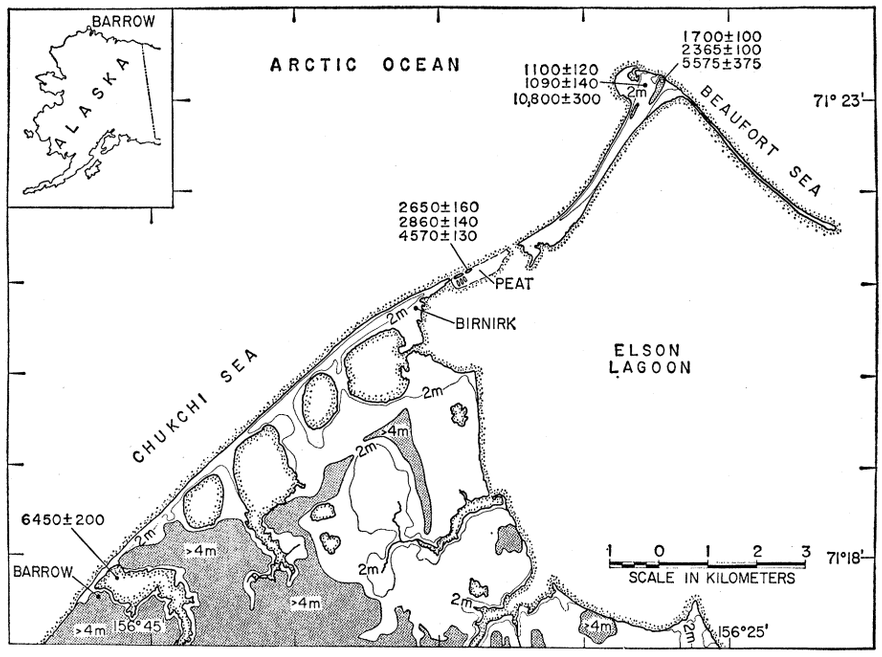

Fig. 1. The Barrow, Alaska, area, showing sources of samples from the spit, radiocarbon ages (years), and 2- and 4-m contour intervals.

The organic section developed in a shallow, predominantly freshwater lake and was encroached upon by the ocean late in its development. Drowning and subsequent burial of the peat occurred as the result of either encroachment of the ocean by inland erosion or a rising sea level. Regardless of the position of the paleo-shoreline, it is unlikely that sea level was higher than the proposed pond during the development of the peat section. This evidence does not agree with a 3-m rise in sea level, shown in Fairbridge's curve, between 2050 and 1450 B.C. (*5*). A substantially lower sea level before the initiation of peat formation is suggested by the age of a wood fragment [6450 ± 200 years (Tx220)] recovered from the base of a black clay layer (−11 m) in the Barrow village estuarine sequence (*6*).

Burial of the small-lake fill by bench gravels was followed by development of the major portion of the spit. On the basis of two series of radiocarbon ages from the spit [1100 ± 120 (I-387), 1090 ± 140 (I-388), 10,800 ± 300 (I-389); 1700 ± 100 (GX 0380), 2365 ± 100 (GX 0381), 5575 ± 375 years (GX 0230)], Hume postulated the following sequence: a rise in sea level to 1 m above that existing to form the oldest and highest ridge sometime after A.D. 265; a presumably rapid fall of 3 m, at which time the Birnirk site was occupied (A.D. 500); a rise of 3 m to form the next youngest ridge (A.D. 1000–1100); and a fall to the present sea level.

Objections can be raised to these relatively rapid rises and falls in sea level, but the present alternatives for the time and mode of formation of this compound ridged spit are only speculative or unsubstantiated. However, a sea level within several meters of that existing has persisted at Barrow since 700

B.C. Further supporting evidence suggests a low sea level between 4000 and 4500 B.C. The Kruzensternian transgression proposed by Hopkins (*7*) appears to be in general agreement with these provisional events.

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29 March 1966

Oligoribonucleotides: Improvement in Chromatographic Separation

Abstract. *The separation of mixed oligoribonucleotides obtained from enzymatic digestion of soluble RNA into fractions containing mixed oligonucleotides of identical chain length is improved by absence of terminal phosphate. Each fraction may be separated into individual components by ion-exchange (Dowex) chromatography. Combination of these two chromatographic procedures yields maximum information on primary structure of the oligonucleotides.*

One of the problems attendant upon characterization of the linear nucleotide sequence of nucleic acids by digestion with specific enzymes is the separation of the resultant mixture of oligonucleotides into individual components. No chromatographic system is known which is capable of resolving all the possible fragments in a single operation. We report here a satisfactory procedure which depends upon preliminary separation of the oligonucleotide mixture on the basis of oligonucleotide length, followed by a chromatographic resolution of fractions containing mixed oligonucleotides of identical chain length (isopleths) into individual components.

Tomlinson and Tener (*1*) reported that pancreatic ribonuclease digests of soluble RNA could be fractionated on columns of DEAE cellulose (*2*) in 7.0*M* urea at *p*H 7.5 with a linear sodium acetate gradient. At this *p*H, and in the presence of concentrated urea, the major binding force is a function of the phosphate residues, and hence fractionation occurs on the basis of oligonucleotide length (number of phosphate residues per oligonucleotide). A similar technique was used by Salas *et al.* (*3*) to separate oligonucleotides of general form (Ap)*n*C utilizing DEAE cellulose and an exponential gradient of NaCl in 8.0*M* urea, 0.01*M* tris-HCl at *p*H 7.8.

Bartos, Sober, and Rushizky (*4*) confirmed these results for pancreatic ribonuclease digests of high-molecular-weight RNA; but they also reported that takadiastase ribonuclease T_1 digests did not give simple and unambiguous resolutions on DEAE cellulose. This was attributed to subfractionation of each isopleth according to the ratio of purine to pyrimidine. The same authors (*5*) further reported adequate resolution of a digest of high-molecular-weight RNA from bacteriophage in 7.0*M* urea, with DEAE-Sephadex as adsorbent.

Our attempts to apply this technique to the study of T_1 ribonuclease digests of serine sRNA from yeast gave the results shown in Fig. 1*a*. The resolution obtained is only partially satisfactory because of increasing overlaps with isopleths of increasing chain length. Various attempts to improve resolution by modification of the elution gradient were unsuccessful, but perfect resolution could be obtained by removal of terminal monoester phosphate from the oligonucleotide fragments. As expected, the dephosphorylated oligonucleotides are eluted at much lower concentrations of NaCl (Fig. 1*b*).

In accordance with the results of Tomlinson and Tener (*1*), fractionation occurs on the basis of the number of phosphate residues per oligonucleotide, and peaks I, II, III, IV of Fig. 1*b* correspond to mono-, di-, tri-, and tetra- . . . nucleotides. The low yields of peaks VI and VIII in Fig. 1*b* are due to the fact that hexa- and octanucleotides are absent from T_1 digests of serine sRNA from yeast.

Hydrolysis of phosphodiester bonds of RNA by T_1 ribonuclease proceeds in two steps: (i) formation of a cyclic 2′,3′-phosphodiester; and (ii) opening of the cyclic bond. In cases where this process ceases after step 1 (for example, methylated guanines, *5*), dephosphorylation by phosphomonoesterase is impossible. Therefore, oligonucleotides consisting of (*n*) nucleotides terminating in a cyclic phosphate are eluted in peak number (*n* + 1) owing to the presence of the terminal phosphate. With this restriction, which may be eliminated by exposure of oligonucleotide fragments to *p*H 2 to open the cyclic 2′,3′-phosphate (*3*) and by further treatment with *Escherichia coli* monoesterase at *p*H 7, the above technique is useful in elucidation of oligonucleotide structure.

Extrapolation from isoplethic origin (that is, oligonucleotides isolated from each *n*th isopleth should contain *n* component bases) serves as an internal check on adequacy of analytical procedures. Deviation in estimation of chain length from values calculated on

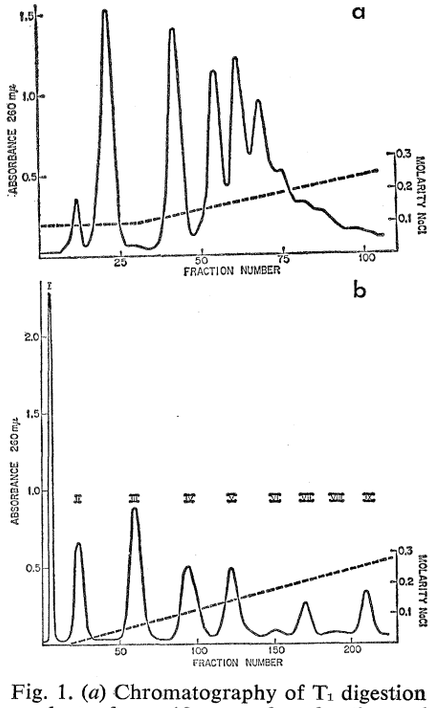

Fig. 1. (*a*) Chromatography of T_1 digestion products from 12 mg of unfractionated yeast sRNA on a column (0.7 by 96 cm) of DEAE-Sephadex A-25, coarse, in 7.0*M* urea, *p*H 8.4; 10-ml fractions. The pattern was unchanged at *p*H 7.6 to 8.4. (*b*) Chromatography of products of digestion with T_1 and phosphomonoesterase of 13 mg of partially purified serine sRNA; DEAE-sephadex column (0.7 by 98 cm) in 7.0*M* urea, *p*H 7.6; 9-me fractions.