Table 1. Growth in length and fresh weight of petioles and shoots of control and handled plants. Data are presented as mean and standard error of mean. Significance of difference was evaluated by two-tailed *t*-test.

	Length			Fresh weight			Days handled (No.)
	Control (cm)	Handled (cm)	Difference (%)	Control (g)	Handled (g)	Difference* (%)	
				Petiole			
No. 1	10.7 ± 0.4	10.0 ± 0.4	N.S.	0.58 ± 0.05	0.61 ± 0.03	N.S.	20
No. 2	17.9 ± 0.3	16.5 ± 0.3	8	1.79 ± 0.11	1.72 ± 0.06	N.S.	13
No. 3	20.0 ± 0.5	15.9 ± 0.5	21	2.32 ± 0.19	1.94 ± 0.10	16	10
No. 4	22.9 ± 0.6	15.8 ± 0.7	31	3.70 ± 0.24	2.69 ± 0.15	27	7
				Shoot			
	10.5 ± 0.5	6.6 ± 0.4	37	3.85 ± 0.35	2.66 ± 0.28	31	

* Percentage differences are significant at the 0.05 level cf probability except where denoted by N.S.

The greatest inhibition of petiole growth occurred among those leaves last to unfold and which were therefore handled least. This suggests that the leaves were at their most sensitive stage before unfolding and that the effect of physical contact was felt by all sensitive regions of the plant, not only by those handled directly.

It is possible that changes in growth pattern induced by handling are responses to ethylene produced as a result of mechanical stress. Ethylene causes a reduction in longitudinal growth but an increase in radial expansion in pea epicotyls (*3*), and is involved in the growth inhibition of etiolated pea epicotyls caused by mechanical resistance (*3*). Ethylene is also involved in the coiling of pea tendrils following contact stimulation (*4*). Mechanical irritation of *Bryonia* shoots decreases the auxin concentration (*5*) which is a well-known ethylene response (*6*).

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Arctic Paleo-Oceanography in Late Cenozoic Time

A recent report by Herman (*1*) describing four Arctic Ocean cores is open to serious criticism in two crucial areas. First, the chronology of the four cores, a prerequisite to any climatic interpretation, is apparently in error. The cores are claimed by Herman to exceed 6 million years in age. Three of the cores (T-3/67-9, 67-11, and 67-12) were also studied by us. Our analysis of magnetic reversals in these *same* cores indicates that they do not exceed 3 million years in age. The results were reported at the Symposium on Late Cenozoic Glacial Ages at Yale University in December 1969 (*2*). The paleomagnetic data are subjected to some scatter but indicate that the cores do not penetrate beyond the Gauss Normal Epoch (3.3 million years ago).

Herman attempted to establish a chronology by correlation with a suite of five cores taken nearby and reported with paleomagnetic data by Steuerwald *et al.* (*3*). Although Herman's longest core was only 3.8 m long, particular emphasis was placed by her on correlation with Steuerwald's core 224, which was 5.6 m in length. The only paleontological or sedimentary information reported by Steuerwald *et al.* for core 224 is the presence of a sharp break between glacial marine and brown lutite sediment at a depth of 4.78 m. This lithologic change is correlated by Herman with a change in her cores which occurs at depths ranging from 1.85 to 2.85 m. Since these cores contain many lithologic changes, the correlation is a tenuous one. A much more acceptable correlation, and one which agrees with our paleomagnetic findings, can be made with the other four cores of Steuerwald *et al.*, for which sedimentary and paleontologic data are reported. These four cores average 2.8 m in length, and their microfaunal fluctuations in abundance correlate reasonably well with Herman's cores. In the upper 1 to 2 m of the cores, the abundance of planktonic foraminiferal tests varies widely. Below a sharp cutoff, whose age was estimated by Steuerwald *et al.* to be about 700,000 years, the cores are nearly barren of planktonic Foraminifera. Steuerwald's four cores are all less than 3 million years in age, which would indicate a similar age for Herman's cores.

The second point in question is the presence of so-called "low-latitude and temperate" species of planktonic Foraminifera in cores raised from the Arctic Ocean. Temperate species (*Globorotalia crassaformis, G. inflata,* and *Globigerinoides* sp.) were first reported by Herman (*4*) in Arctic cores, and subsequently she recognized such low-latitude species as *Globorotalia menardii, G. tumida, Globigerinoides ruber, Globigerinoides* sp., *Sphaeroidinella dehiscens,* and *Globoquadrina dutertrei* (*1, 5*). The last group is known to live predominantly in tropical and subtropical waters. Her drawings (*5*) of *Globigerinoides* sp., cf. *G. sacculifer Globigerinoides* sp., cf. *G. ruber*, and *Globorotalia crassaformis* are not diagnostic, and none of the other "tropical" species have been figured. We have searched at Lamont for such species at the indicated levels in the *same* Arctic cores. The only two species of planktonic Foraminifera identified by us were *Globigerina pachyderma* and *G. quinqueloba*, which are polar and subpolar species, respectively. It should be noted that neither Ericson *et al.* (*6*) nor Steuerwald *et al.* (*3*) have found any tropical or subtropical species in their Arctic cores.

Any warming trend in the Arctic Ocean that would lead to the purported appearance of tropical species should have been accompanied by a series of successions of foraminiferal assemblages. A progressive displacement of the polar species by a subpolar assemblage (dominated by *Globigerina bulloides*), by a temperate assemblage (dominated by *Globorotalia inflata*), which in turn should have been replaced by a subtropical assemblage (with mainly *Globorotalia truncatulinoides, G. hirsuta,* and so forth) should have occurred before the appearance of a tropical assemblage (*Globorotalia menardii, Sphaeroidinella dehiscens,* and so forth). We have found no such successions, as *Globigerina pachyderma* has been the dominant species during the last 2.5 million years. There have been only slight invasions of subpolar waters, as indicated by small percentages of *G. quinqueloba* and rightcoiling *G. pachyderma*. Thus, we speculate that Herman's "tropical and subtropical" species are based on misidentification of small, atypical specimens or that they were laboratory contaminants.

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I was delighted to read that the long-standing controversy concerning the evolution of Arctic climates in Late Cenozoic time has been resolved and that Hunkins *et al.* have now reversed their interpretation presented at the Symposium on Late Cenozoic Glacial Ages at Yale University, December 1969, and have accepted mine.

My contentions, paraphrased by Hunkins *et al.* (*1*), are:

1) That there is no detectable evidence of climatic changes during the last 70,000 years in the Alpha Rise cores studied to date, and hence that the topmost foraminifera-rich sediments represent pack ice covered conditions (*2–5*).

2) That the foraminifera-poor and Mn,Fe-poor zones, most prevalent during the Matuyama Epoch, represent periods warmer than those prevailing today (*2–5*).

3) That the deposition of Mn-rich, foraminifera-poor sediments [my unit III (*2–4*)] occurred during periods when the Arctic deep water was oxygenated and rates of solution of calcareous tests were higher than today.

The first criticism of Hunkins *et al.* concerns the time scale presented in my recent report (*2*). In this report I stated that ages were estimated by interpolations and extrapolations with neighboring cores that have an established paleomagnetic stratigraphy. I further stated that "age assignments . . . are based on a small number of measurements and should therefore be considered provisional and subject to modification as additional radiometric and paleomagnetic determinations become available" (*2*). Reinterpretation of the paleomagnetic data of core 224, upon which my time scale was based, by Clark (*6*) suggests that the earlier paleomagnetic ages (*7, 8*) were apparently overestimated. Consequently, a modified chronology for the T3 Alpha Rise cores has been presented (*3, 4*); according to the new data, the time interval represented by the longest core, T3-67-12, exceeds 3 million years. This age, based on "tenuous correlations," is very similar to that suggested by Hunkins *et al.* Although several lithologic changes were recognized in these cores (*2, 5*), the most conspicuous is the change from brown lutite to glacial-marine sediment (*7*). The contact between these two sediment types, described by Steuerwald *et al.* (*7*), corresponds to my unit III/II boundary and was recognized in all Alpha Rise T3 cores (*2*). This prominent and unique lithologic change is matched by alterations in faunal composition, distinguishing unit III from the younger units II and I. Thus, this horizon provides a very important means of correlation between cores. As demonstrated in my report (*2*) and elsewhere (*3–5*), core length has no bearing on the validity of correlations between cores. Faunal and lithologic characteristics interpreted in the light of topographic setting, rates of sedimentation, and postdepositional history are generally employed in biostratigraphy for intrabasinal correlations.

The second criticism of Hunkins *et al.* regards my finding and reporting mixed, low-latitude planktonic foraminifers together with sinistral *Globigerina pachyderma*. This occurrence, although interesting, was difficult to account for. However, Hunkins *et al.* (*1*) report up to 50 percent of dextral populations of *G. pachyderma* in Arctic sediments. If their identification is correct, then Arctic surface water temperatures were at least 9° to 12°C higher than those of today. The presence of low-latitude forms is accounted for by Hunkins' own data and hence their criticism is invalid.

It would have been valuable if Hunkins *et al.* had described their method of search for low-latitude foraminifers. The procedure utilized for faunal analysis greatly affects the results obtained. The procedure used in my laboratory has been described (*5*), and a staining method has been developed to facilitate and expedite faunal analysis in Arctic cores (*9*). Hunkins *et al.* mention the presence of "small percentages" of *Globigerina quinqueloba* in T3 cores studied by them. I have studied *the same cores* and found that *G. quinqueloba* is a major faunal component, constituting up to 99 percent of the fauna (*2, 4*). For example, there are almost 100,000 specimens (94,830) of *G. quinqueloba* in a total of four standard size samples of Lamont core T3-67-11. A maximum count of 33,100 specimens was obtained for a sample weighing 1.26 g. In consideration of these data, it is difficult to explain why my results are in such strong disagreement with those of Hunkins *et al.*

As to the criticism regarding the lack of diagnostic features in the illustrations in my previous publication (*5*), my opinion differs from that of Hunkins *et al.*, and it is for the reader to judge whether the camera lucida drawings are or are not diagnostic. Excellently preserved adult specimens of *Globorotalia crassaformis* from Arctic cores were deposited in the Lamont core laboratory and are available for inspection.

For these reasons I must reject the criticisms raised by Hunkins *et al.*; however, I thank the authors and R. Capo for their interest in my work and for collecting, sampling, and shipping the core samples to Washington State University.

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