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Cover Page Footnote
This study was made possible by a research grant from Sigma Xi, the Scientific Research Society, and by the help of two friends, J. Shoshani and C. T. Madden.

ENAMEL PRISM PATTERNS IN PROBOSCIDEAN MOLAR TEETH

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ABSTRACT: Molar fragments of five proboscidean taxa, representing three families, were examined under the scanning electron microscope for their enamel prism patterns. (Three of the five examined are extinct.) Results show that enamel prisms of Deinotherium are the least dense, whereas the prisms of the Elephantidae genera (Loxodonta, Elephas and Mammuthus) are the most dense, with the enamel prisms of Gomphotherium being intermediate in their density. No significant variations were found among Elephantidae genera. These observations correlate with those of earlier workers (e.g., Osborn, 1942) in that many of the morphological changes used to separate elephants (sensu stricto) from other proboscideans are the result of an evolutionary trend in diet, from the predominately browsing animals (having brachyodont thick-enamel molar teeth) to the predominately grazing animals (having hypsodont thin-enamel molar teeth).

INTRODUCTION

In the appendix of Henry Fairfield Osborn's posthumous monograph on the Proboscidea, George Gaylord Simpson wrote of the potential importance for a comparative study of proboscidean dental histology. It was recognized that the microstructure of the dental tissues might vary between taxa in such a way as to be useful in a taxonomic classification. Moreover, Simpson states (1942, page 1607); "There is also good reason to believe that the histological characters may be of value in the identification of fossils and in the determination of animal affinities". In this appendix, Simpson was reporting on an incomplete study undertaken by Osborn and his colleagues investigating histological differences of the incisor teeth between three proboscidean genera: Elephas, Phiomia, and Trilophodon. Their preliminary results indicated that the three genera were distinct from one another, but also that the one elephant (sensu stricto) genus, Elephas, differed greatly from the other two extinct genera. These results were consistent with the current taxonomic classification. Although this study did not include a comparative study of the molar teeth, Simpson clearly noted the potential for correlating variation at the microstructural level with the variation seen at the macrostructural level in the molar teeth.

The family Elephantidae is well known for its adaptive shift in feeding strategies as evidenced by molar morphology; its phylogenetic position within the Proboscidea is shown in Fig. 1. Osborn (1942) noted the progression from a predominantly browsing diet to a predominantly grazing diet as indicated by the change from brachyodont, thick-enamel, molar teeth to more hypsodont, thin-enamel, teeth. Thus, many of the morphological characters that are used to differentiate the elephants (sensu stricto) from other proboscideans

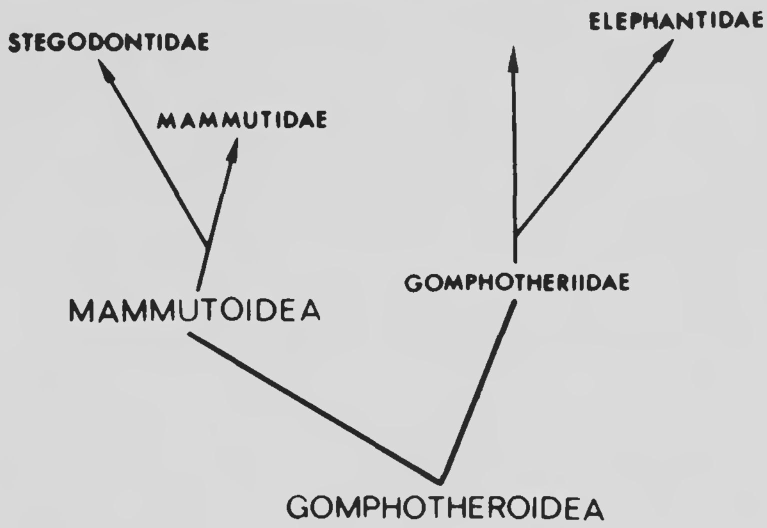

Figure 1. Proboscidean phylogeny (after Maglio, 1973:6). [Note that Gomphotheroidea is a misprint; it should be Gomphotherioidea. According to Tassy (pers. comm.), however, Elephantoidea would have been a better term.

are the result of this evolutionary trend in diet.

In this report, an attempt was made to correlate variation in the enamel prism patterns at the microstructural level with variation in the molar morphology of certain proboscideans. Since the transition from brachyodont to hypsodont molar teeth was to be examined, the molar teeth from Gomphotherium and Deinotherium were selected to represent the thick-enamel brachyodont moiety. Representing the hypsodont thin-enamel moiety are three genera of the family Elephantidae; Elephas, Mammuthus, and Loxodonta. It is hypothesized that the hypsodont thin-enamel dentition of the Elephantidae reflects a corresponding change in the microstructure of the enamel.

MATERIALS AND METHODS

Fragments of molar teeth from five proboscidean taxa were examined; these include:

Deinotherium sp.	- Deinotheriidae; Extinct; Miocene epoch of Africa, British Museum No. M21948.
Gomphotherium angustidens	- Gomphotheriidae; Extinct; Miocene epoch of France, British Museum No. M7602.
Loxodonta africana	- Elephantidae; Extant; Recent (or Holocene epoch) of Africa.
Elephas maximus	- Elephantidae; Extant; Recent (or Holocene epoch) of Asia, (fragment of "Iki"'s molar)*.
Mammuthus meridionalis	- Elephantidae; Extinct; Pleistocene epoch of England, British Museum no number.

*"Iki" was dissected at Wayne State University, See Elephant, 2(1):3-93.

Small facets on the crown surfaces of the molar fragments were first polished, and then cleaned in acetone and alcohol baths. Subsequently, the facets were chemically etched with a solution of ortho-phosphoric acid. The specimens were coated with a gold-palladium alloy for viewing in the scanning electron microscope (SEM). Micrographs were then taken in order to document the variation in the enamel prism patterns.

RESULTS AND DISCUSSION

The taxa examined in this study exhibit the same fundamental "open arcade" enamel prism pattern described by Alan Boyde (1969) for Loxodonta, and by Yukishige Kozawa (1977) for Elephas. Among the five taxa, variations in the shape and size of the prisms do occur, but these are the consequence of the different angles at which the enamel prisms emerge at the crown surface. Prism decussation, where the enamel prisms change direction, is seen in all taxa examined. In Deinotherium the prism decussation is not as elaborate (see Fig. 2) as in the Elephantidae (especially Mammuthus), where the prism decussation is much more elaborate and pronounced (see Fig. 3). Among the Elephantidae, Mammuthus appears to be slightly more elaborate than Elephas and Loxodonta, between which no distinction could be made.

Besides the amount of prism decussation, the most striking observations which serve to distinguish the Elephantidae from Deinotherium and Gomphotherium are the density of the general prisms and the amount of "inter-prismatic" enamel (compare Figs. 4-8). In the Elephantidae the prism density is much greater and there appears to be no "inter-prismatic" region (Figs. 5, 6 and 7), whereas in the other two taxa, Deinotherium and Gomphotherium, the prism density is less and there appears to be a well-defined region separating the rows of enamel prisms (Figs. 4 and 8). Deinotherium differs from Gomphotherium in having even less prism density and even more "inter-prismatic" enamel (compare Figs. 4 and 8). Thus Gomphotherium appears to be intermediate between Deinotherium and the elephants with respect to the prism density and inter-prismatic enamel.

Variations among the Elephantidae genera (Loxodonta, Elephas, and Mammuthus) in terms of prism decussation and prism density appear to be insignificant. Inability to distinguish among the Elephantidae genera has also been observed by other workers using morphological (Valente, 1983) and biochemical data (Prager et al., 1980; Shoshani et al., 1985).

Prism decussation, which is the result of differential movement of zones of ameloblasts during the ontogenetic development of the enamel, could conceivably reinforce thin enamel thereby preventing stress cracks penetrating the thickness of the enamel (Boyde, 1969). Also, by increasing the prism density, enamel could posssibly be further reinforced to withstand the forces generated during mastication. Thus, in the elephants (sensu stricto), the relatively large plates with thin-enamel would benefit mechanically during mastication from increased prism density and more elaborate prism decussation.

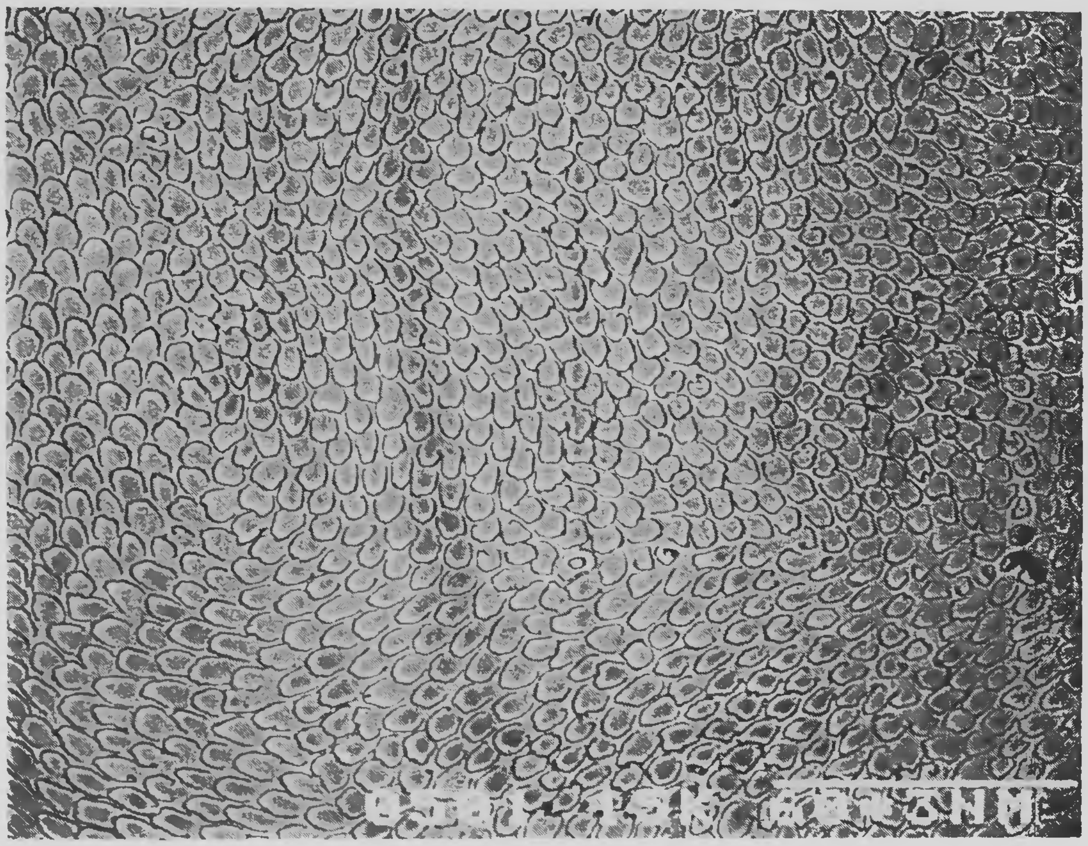

Figure 2. Enamel prism pattern of *Deinotherium* sp. magnified 501 times. Unlike the elephants, this micrograph demonstrates a gradual and less complex prism decussation.

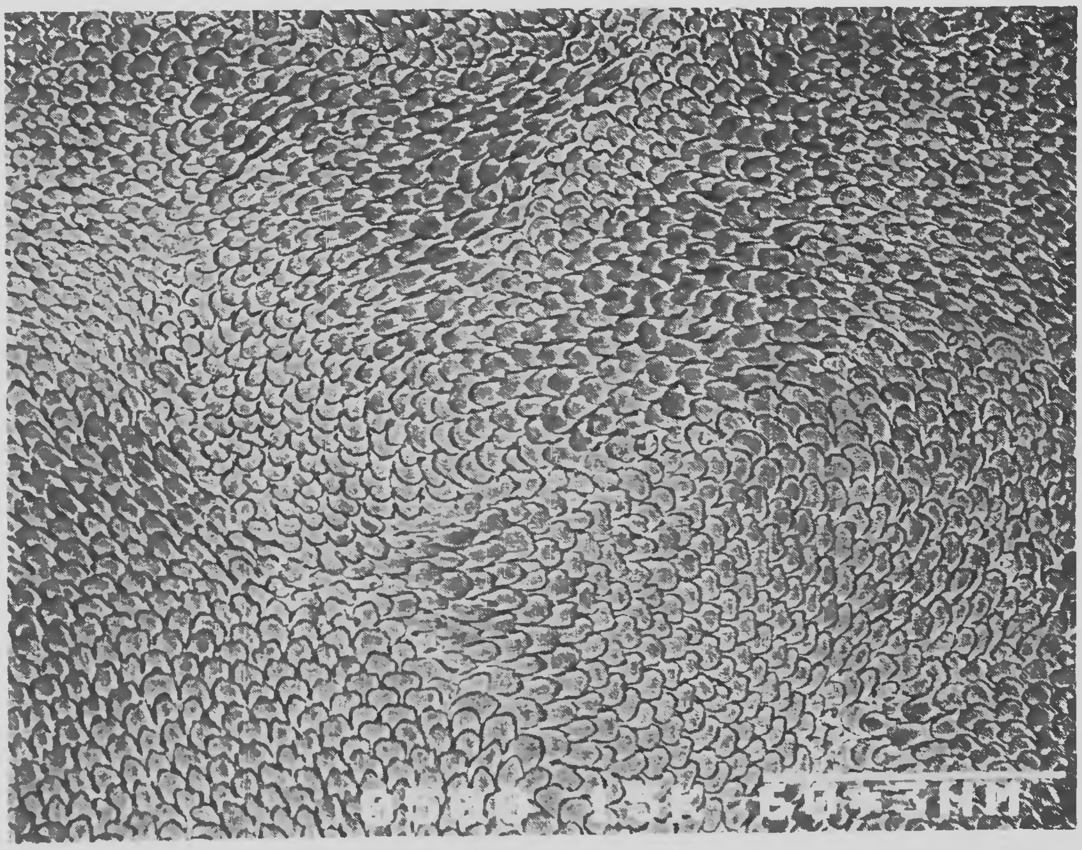

Figure 3. Enamel prism pattern of *Mammuthus meridionalis* magnified 500 times. This micrograph demonstrates a tremendous amount of prism decussation (changes in prism direction) seen in the elephants generally and in *Mammuthus* specifically.

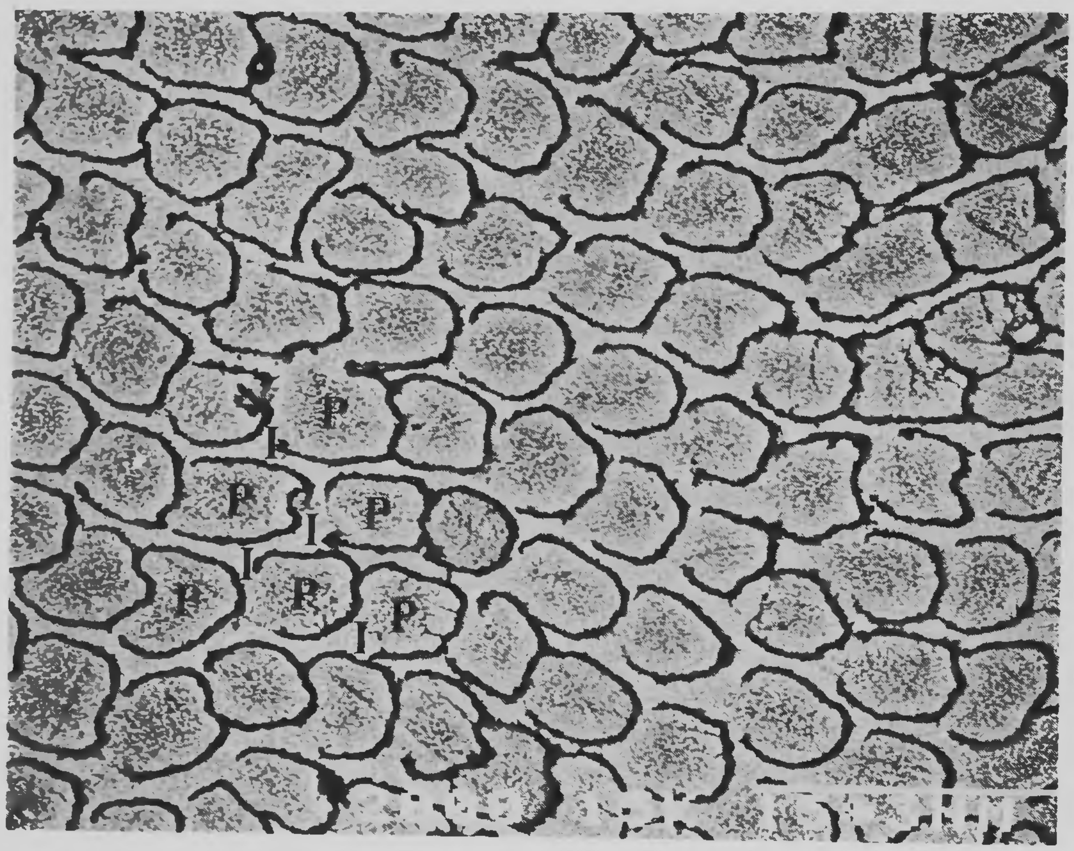

Figure 4. *Deinotherium* sp. magnified 2,000 times. In this micrograph, the prism density (P), when compared to that of other proboscideans, is much less, leaving a well defined inter-prismatic region (I).

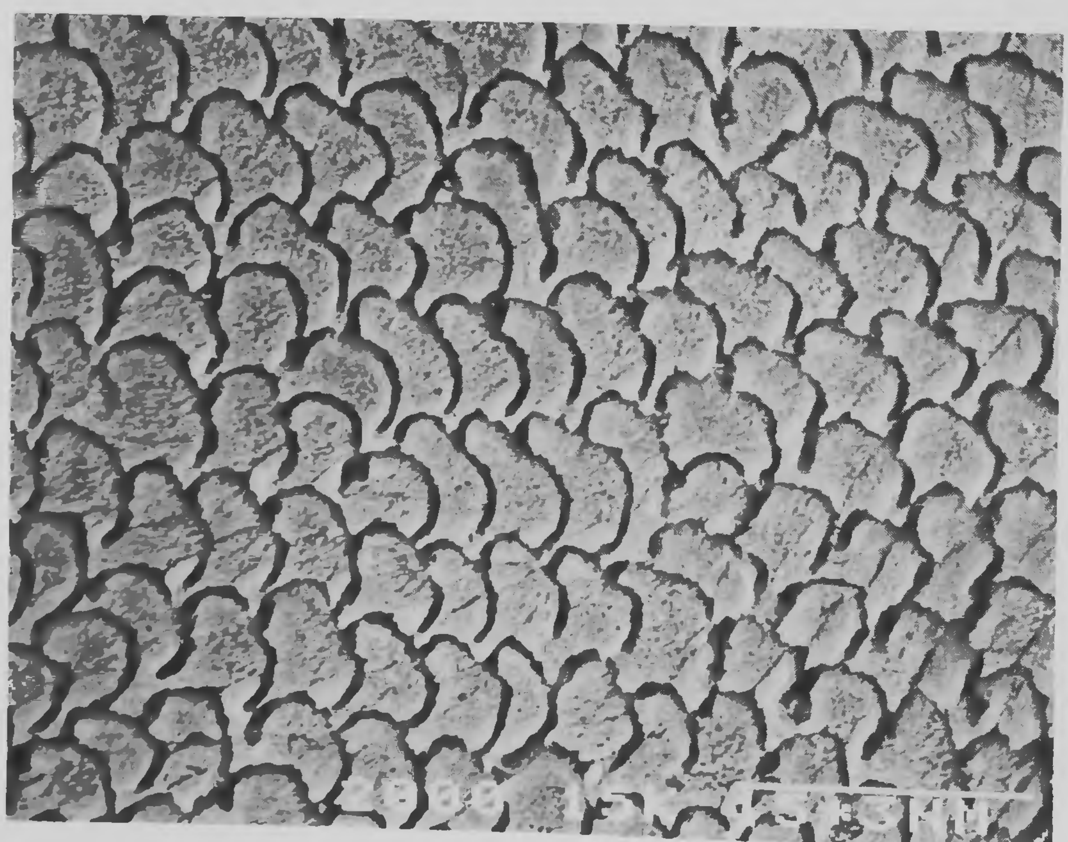

Figure 5. *Mammuthus meridionalis* magnified 2,000 times. In contrast to *Deionotherium*, the relatively great prism density precludes any inter-prismatic region.

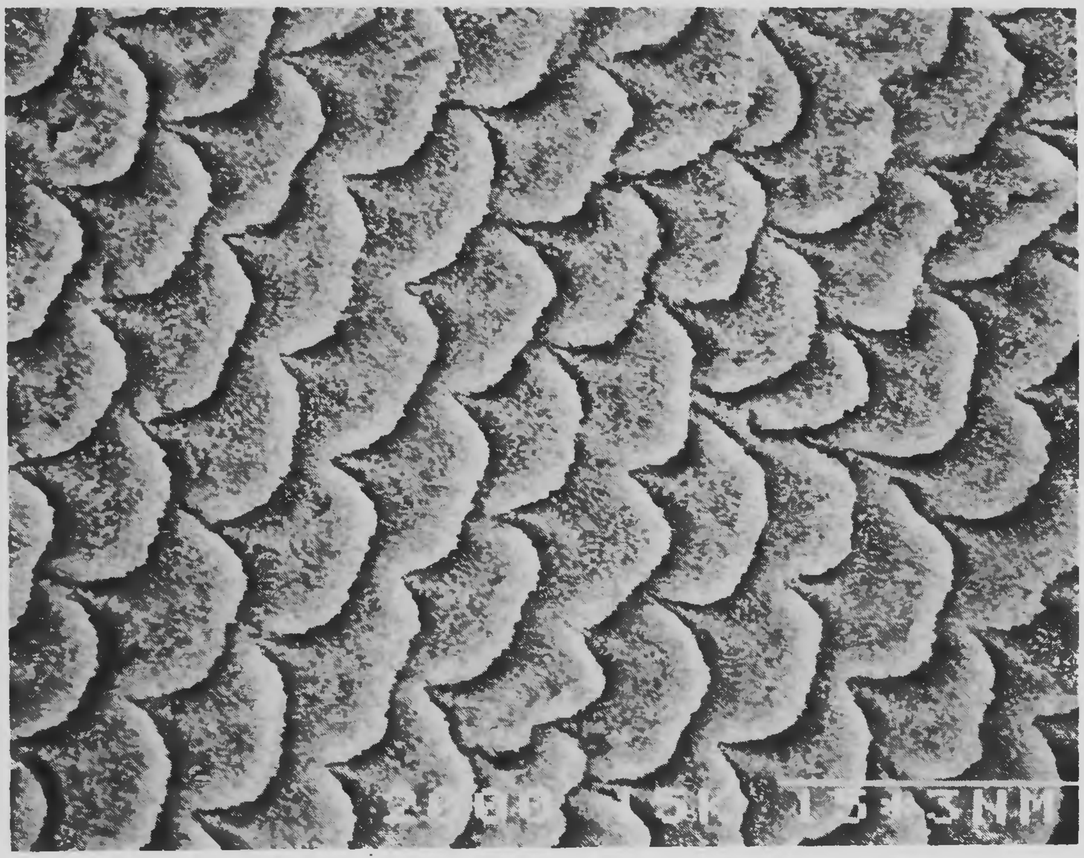

Figure 6. *Loxodonta africana* magnified 2,000 times. As seen in *Mammuthus* and *Elephas*, the prism density is greater than in *Gomphotherium* and *Deinotherium*.

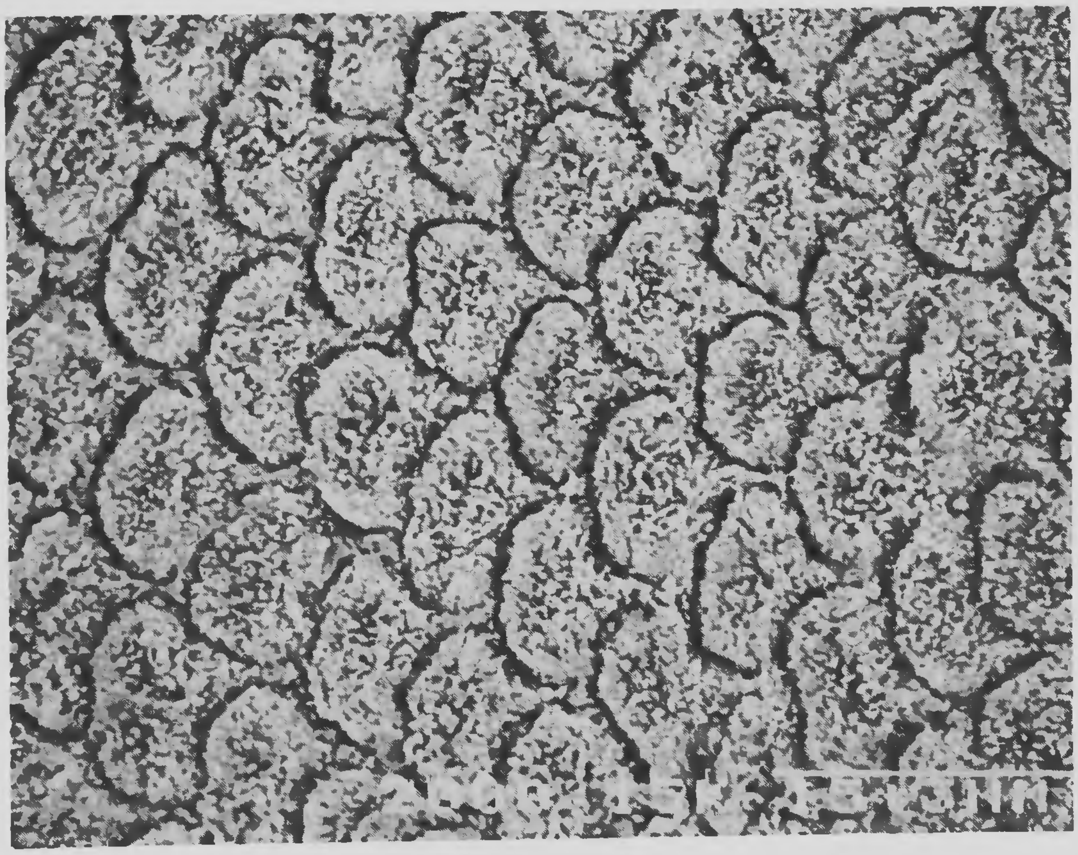

Figure 7. *Elephas maximus* magnified 2,000 times. Similar to that of *Loxodonta* and *Mammuthus*.

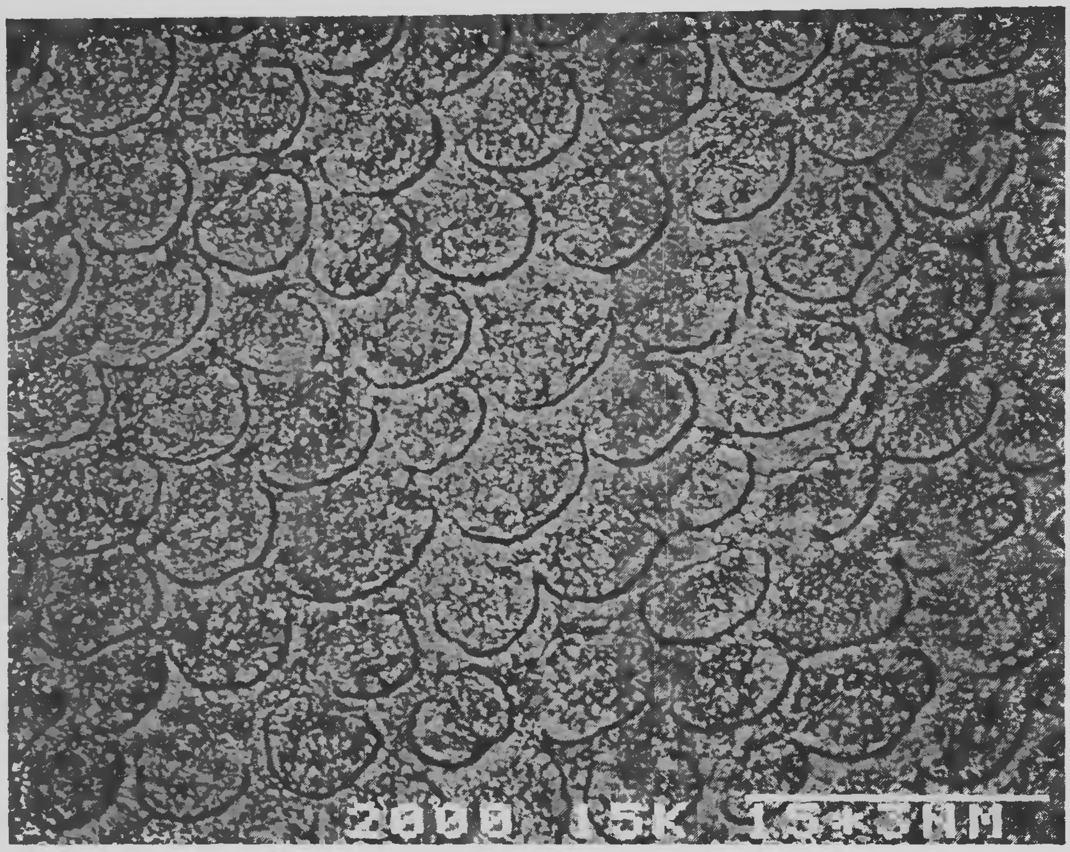

Figure 8. Gomphotherium angustidens magnified 2,000 times. Gomphotherium enamel appears to be intermediate between the elephants and Deinotherium as seen above.

Currently, research into the origin of the Elephantidae is being conducted by examining the most primitive elephant Stegotetrabelodon and other members of this taxonomic family. In order to distinguish between character similarity due to function and that due to phylogeny, the Stegodontidae are being included. The stegodonts were once considered to be the stem group for the elephants, but now this Asiatic group is thought to be entirely convergent and not related to the elephants (sensu stricto) (Fig. 1; see however, Tassy, 1983, for relationships of Stegodontidae to Elephantidae). Much further research is needed in order to understand the evolution of dental enamel in the mammalian order Proboscidea.

ACKNOWLEDGMENTS

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LITERATURE CITED

Boyde, A. 1969. Electron microscopic observations relating to the nature and development of prism decussation in mammalian dental enamel. Bull. Group Int. Rech. Sc. Stomat., 12:151-207.

Kozawa, Y. 1977. Variations of enamel structure in elephant molar teeth as observed by scanning electron microscopy. Nihon Univ. J. Oral Sci., 3:193-199.

Maglio, V. J. 1973. Origin and evolution of the Elephantidae. Trans. Amer. Phil. Soc., 63(3):1-149.

Osborn, H. F. 1942. Proboscidea. Amer. Mus. Press, New York, Vol. 2:805-1675.

Prager, E. M., A. C. Wilson, J. M. Lowenstein, and V. M. Sarich 1980. Mammoth albumin. Science, 209:287-289.

Shoshani, J., J. M. Lowenstein, D. A. Walz, and M. Goodman. 1985. Proboscidean origins of mastodon and woolly mammoth demonstrated immunologically. Paleobiology, 11(4):429-437.

Simpson, G. G. 1942. Proboscidean dental histology (Appendix to Volume II). Pp. 1607-1608, in Proboscidea (by H. F. Osborn). Amer. Mus. Press, New York, Vol. 2:805-1675.

Tassy, P. 1983. Les Elephantoidea miocenes du Plateau Potwar Groupe de Siwalik, Pakistan. Ann. Paleont., 69(2):99-136; (3):235-297; (4):317-354.

Tassy, P. November 1986. Personal communication.

Valente, A. 1983. Hair structure of the woolly mammoth, *Mammuthus primigenius*, and the modern elephants, *Elephas maximus* and *Loxodonta africana*. J. Zool., London, 199:271-274.