jee now agree with others ". . . that the pollen of corn cannot be distinguished from teosinte by their spinule patterns which are quite similar, the only criterion for making a distinction is one of size" (*9*). It is therefore entirely reasonable to assume that the five largest pollen grains of the 14 recovered in the Mexico City drill-core sample are diploid grains produced by tetraploid teosinte rather than diploid grains from wild corn. Thus there is no solid evidence that a wild corn other than teosinte ever existed.

I have tested this possibility experimentally by treating teosinte plants with the drug colchicine, which induces polyploidy. Plants of 244 annual diploid teosintes, adapted to Chicago summer latitudes but otherwise indistinguishable from wild teosintes, including pollen size, were treated with colchicine in the expectation of inducing pollen approximately double the volume of controls. These plants were grown during the summer of 1980 in greenhouse compartments isolated from all corn pollen. Ten plants each produced some large pollen with a volume approximately double that of pollen grains from untreated controls (Table 1). In sum, 419 large pollen grains were measured. The remaining 234 plants yielded only pollen of essentially normal size. These and the normal pollen grains among plants with large pollen also serve as controls. However, pollen grains from untreated controls were also measured with no large pollen detected.

It seems most improbable that the colchicine-induced large pollen grains did not carry two sets of chromosomes, but it would have been even more remarkable if all 419 pollen grains were then so closely double the volume of their ten-chromosome controls. It should be emphasized again that newly arisen tetraploid corn plants produce pollen whose volume is twice that of their diploid controls and that teosinte is now said to differ taxonomically only at the subspecies level.

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References and Notes

1. To avoid possible confusion in use of common and taxonomic names of corn and teosinte, I shall use the following: corn, Indian corn or maize, taxonomically: *Zea mays* subspecies *mays*; postulated wild corn believed to be extinct or conceivably still undiscovered; and teosinte of four species, including *Zea mays* ssp. *mexicana*, presumed to be the direct ancestor of cultivated corn.
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12. I thank my associates in the Biology Division of the University of Chicago for encouragement in this attempt to solve the long-standing problem of the origin of corn. David Toub, an undergraduate in the Department of Biology, assisted in inducing tetraploidy in teosinte by colchicine treatments. Professors James A. Teeri and Edward D. Garber have assisted and encouraged me. Professor D. E. Alexander of the University of Illinois, Urbana, referred me to the unpublished master's thesis of J. A. Cavanah, at the University of Illinois, Urbana, who then permitted me to refer to it. I am indebted to the individual referees who reviewed my account and significantly improved my presentation.

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Magnetic Material in the Head of the Common Pacific Dolphin

Abstract. *Magnetic material carrying natural remanent magnetization is present in the head of the common Pacific dolphin (*Delphinus delphis*). A sample of this material, isolated from the dura mater, has a moment of 2×10^{-5} gauss–cubic centimeter. The presence of such strongly magnetized material suggests that it may play a navigational role.*

Evidence has been accumulating that certain organisms use the geomagnetic field as a navigational aid. Probably the most convincing data are provided by studies on magnetotactic bacteria (*1–3*), bees (*4, 5*), and homing pigeons (*6, 7*). All these organisms contain magnetite (*8, 9*). In the homing pigeon, some of the magnetite occurs between the dura mater and the skull. We now report the discovery of magnetite in the head of the common Pacific dolphin (*Delphinus delphis*). This appears to be the first reported occurrence of magnetite in a mammal. The dolphins were obtained from the Los Angeles County Museum of Natural History through a program whereby dead stranded marine mammals are collected for research.

The head of the animal was cut into five 2.5-cm-thick coronal sections with a Stryker autopsy saw. These were cut parasagittally to give elongated sections that could conveniently be measured in a horizontal-access SQUID magnetometer (*10*). All the sections were detectably magnetized, with one section markedly more magnetic than the others. This section included the supraoccipital region, approximately 2 cm posterior to the ridge formed by the junction of the occipital, parietal, and frontal bones [the skull configuration of cetaceans differs from that of most mammals due to the so-called telescoping effect (*11*)].

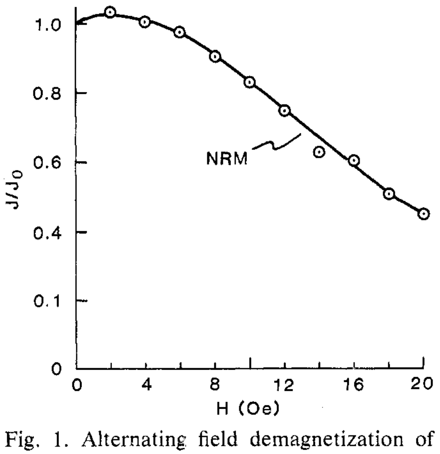

Fig. 1. Alternating field demagnetization of the tissue sample NRM. Abbreviations: J_0, initial magnetic moment; J, magnetic moment after demagnetization; H, magnetic field (alternating); and *Oe*, oersted.

The magnetic tissue is located in the falx cerebri, which in the dolphin is considerably ossified. The posterior part of the falx forms, with the tentorium cerebelli, a substantial septum separating the cerebrum from the cerebellum. The magnetic material was found on the left side of the falx cerebri between the roof of the skull and the juncture of the falx with the tentorium. We separated the dura from the bone with a stainless steel scalpel and isolated a few cubic millimeters of magnetic tissue. The moment of this sample was 2×10^{-5} gauss-cm^3 (2×10^{-8} A-m^2).

We sectioned a second dolphin head in the same manner and found, within the dura in the same region, another strongly magnetized piece of tissue. In all, five dolphins were studied and, with the exception of one that was so badly decomposed that the dissection was not satisfactory, each contained comparably magnetized tissue. However, it was not always found in precisely the same place. For example, in one animal the magnetized dura was on the right tentorium near the junction of the tentorium and the skull.

The natural remanent magnetization

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(NRM) was subjected to alternating field demagnetization and found to be soft, being substantially demagnetized by fields of a few oersteds (~10^2 ampere turns per meter) (Fig. 1). The NRM of the fine particles that carry the paleomagnetic record in rocks would be essentially unaffected by such fields. There is some variability in the NRM of dolphin tissues, but it is all magnetically soft. The acquisition of remanent magnetization, the demagnetization of saturation remanence, and the remanent coercive force are all indicative of magnetically soft material.

Although identification of the magnetic material is incomplete, it is at least in part magnetite. Strongly magnetized tissue from one of the dolphins contained an opaque, disklike particle visible to the naked eye. The particle is iron-rich, with no detectable nickel or chromium. That the particle is indeed magnetite was shown by a low-temperature test for multidomain magnetite (*12*). The magnetic properties of the particle are strongly anisotropic, which is consistent with the known behavior of this kind of magnetite particle.

The particle was studied by scanning electron microscopy at the U.S. Steel Research Center. Figure 2, a and b, shows the particle before and after tissue was removed from its surface. Figure 2c shows the exposed surface of the particle. On this surface are fibers with diameters of approximately 1 μm and others about one-tenth that size. They appear to be nerve fibers. Figure 2d is an expanded view of a region rich in fibers. In the field of view is a roughly circular structure with an elevated margin. Protruding from the center of the structure is a large stalk-like object, and within and around the structure are small fibers. The fibers

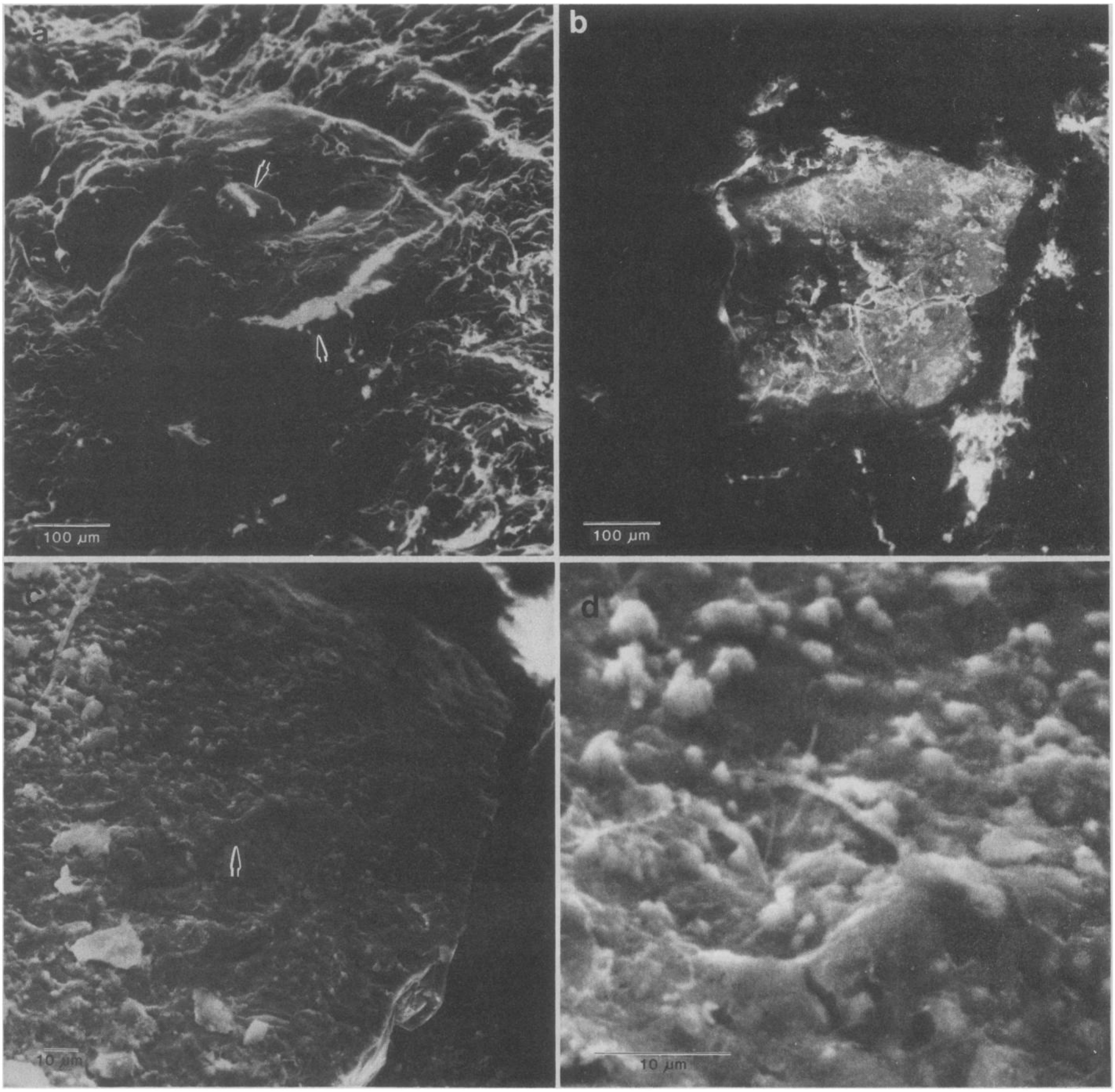

Fig. 2. Electron microscopy of the large magnetite particle. (a) Particle embedded in tissue; white streaks on the particle are beam damage. (b) Particle with tissue partially removed. (c) Enlargement of part of the exposed surface. (d) Enlargement of structure indicated by arrow in (c).

may be a nerve net and the large object could be part of a magnetic receptor.

In other dolphins no large particles were found which permitted the type of analysis described. These samples did not exhibit the multidomain magnetite transition on warming from liquid nitrogen temperature, but showed a gradual decrease of magnetization. This is consistent with the presence of fine superparamagnetic and near superparamagnetic single-domain magnetic material.

We conclude that certain dolphins have magnetic material in their dura mater. Some of this is magnetite and may be used as a magnetic field receptor. However, the material is so magnetically soft that it is unlikely to be analogous to a permanently magnetized compass needle. Still, a soft anisotropic magnetic material will experience a torque in the geomagnetic field because of its induced moment. This could serve as a basis for field detection. Alternatively, the seemingly fragile nature of the material suggests that it might deform in the earth's field. This, too, could be utilized for field reception (*4*). We do not know whether the magnetite is part of a field receptor system or whether dolphins can detect a magnetic field. Nevertheless, the association of apparent nerve fibers with the magnetite suggests that the magnetite is not simply a metabolic by-product but has a sensory function.

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Stromatoporoid Growth Rhythms and Rates

Abstract. *Stromatoporoids are major contributors to framework construction in Paleozoic reefs. The Devonian species* Parallellostroma densilaminata *(Fagerstrom),* P. winchelli *(Galloway and Ehlers), and* Stictostroma *sp. form large rhythmically structured colonies that competitively overgrow corals. Their competitive interactions and important role as reef builders place considerable value on growth rate information. Identification of common growth periods in these interacting species provides a method for quantifying vertical and lateral stromatoporoid growth and a means for identifying an annual periodicity of calcification.*

Organisms that secrete accretionary skeletons record rhythmic motions of an astrophysical or geophysical nature if there is differential growth over the duration of the rhythmic event. Deposition of new material in these organisms occurs along the skeletal margins exclusively (*1, 2*) and in direct response to regular environmental changes that accompany rhythmic phenomena (*2, 3*). Two rates of physical growth usually exist, each producing a characteristic structural density of hard parts (*3–5*). Consequently, all such organisms have skeletons imprinted with a structural periodicity matching that of some external rhythm. Although the ecological factors that influence the biomineralization processes remain unknown, the skeletal structural periodicity constitutes a long-term growth rate record that can be measured once the periodicity of the rhythm is identified.

Parallellostroma densilaminata (Fagerstrom), *P. winchelli* (Galloway and Ehlers), and *Stictostroma* sp. are three encrusting stromatoporoids which, along with corals, are major frame builders in middle Devonian patch reefs of Michigan. All of the stromatoporoids are frequently found encrusting corals either as a postmortem or competitive overgrowth (*6*). Each of the mantling stromatoporoids has a massive skeleton (coenosteum) with internal structures of two distinct but unknown frequencies. The fundamental cyclic structure (laminae), which is not always clearly distinguishable, consists of a thin sheet of calcareous skeletal elements. A longer duration rhythmic structure (latilaminae) is defined by bands of closely spaced laminae. These make up concentric sheets with a maximum thickness of 1 to 7 mm. Succeeding latilaminae are characteristically distinguished by a variation in color and an accompanying increase in laminae density. This kind of physical change in growth suggests that stromatoporoid skeletogenesis was rhythmic in nature and responsive to some external rhythm with a matching periodicity. There is also an indication that skeletal calcification was rapid. The competitive overgrowth of one organism by another must involve differential growth along interspecific skeletal margins (*7*). Thus, there is the implication that stromatoporoids grew faster than the corals they mantled.

Both hypotheses can be evaluated by the use of competitively intergrown specimens to define common periods of growth. Fossils recording this type of interaction bring the known periodicities of coral skeletons (coralla) (*4, 5, 8*) into juxtaposition with the unknown periodicities of rhythmically organized, mantling, stromatoporoid coenostea. Growth periods common to both animals are readily defined by two or more successive steplike interfaces that involve bas-

Table 1. Stromatoporoid growth rates.

Stromatoporoid and coral species	Total number of individual specimens	Coral growth (mm/year)	L_s/V_c	V_s/V_c	Stromatoporoid growth	
					Lateral (mm/year)	Vertical (mm/year)
P. densilaminata on *F. alpenensis alpenensis*	5	10.6	2.18	0.23	23.1	2.5
P. densilaminata on *Thamnopora* sp. A	1	7.9	1.67	0.33	13.2	2.2
P. densilaminata	13					2.5*
P. winchelli on *F. alpenensis alpenensis*	1	11	1.43	0.27	15.7	3.0
P. winchelli	35					3.8*
Stictostroma sp. on *Thamnopora* sp. A	5	7.9	1.32	0.16	10.4	1.3

*Latilaminae measurements