Table 1. Ratios of natural thermoluminescence to sensitivity (TL_{max}/S) for pottery subsamples of various present-day ages. Standard deviations of the means are given. Numbers of samples appear in parentheses. The Sechin Plain pottery is Colonial to Tiahuanaco in period; Salinas Plain, Late Classic; Patazca Polished Plain, Late Formative; Gualaño Black Plain, Middle Formative; Cahuacucho Thick Red, Early Formative.

Pottery		TL_{max}/S (mean)
Type	Age (yr)	
Sechin (6)	400–1100	.76 ± .27
Salinas (4)	1300	.98 ± .19
Patazca (4)	2400	1.90 ± .62
Gualaño (5)	2800	2.28 ± .77
Cahuacucho (3)	3000	2.21 ± .65

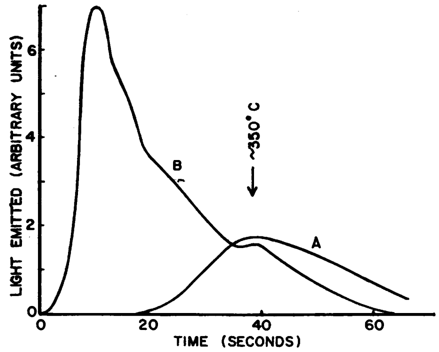

Fig. 1. Glow curves of the natural thermoluminescence (*A*) and of thermoluminescence induced by a standard x-irradiation (*B*) for a typical sherd; black-body radiation was subtracted from both. Arrow indicates the point at which both TL_{max} and S are measured.

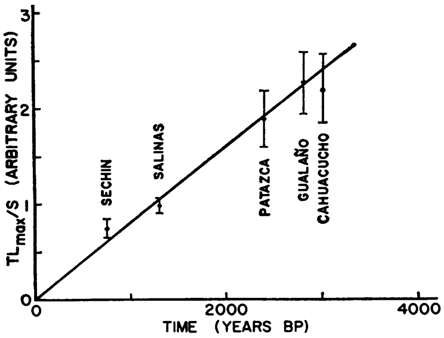

Fig. 2. Ratio of natural thermoluminescence to sensitivity (TL_{max}/S) plotted versus the age of the pottery. Means for the pottery subsamples are represented by dots; bars indicate standard errors.

among sherds from the same site. To get a better value for the age indicator it was decided to concentrate on measuring the parameters that varied the most: thus the TL_{max} and S were measured for several samples from the same area, and the average TL_{max}/S was taken as an indicator of age. This method eliminated the costly and time-consuming process of measurement of total radioactivity.

Thermoluminescence not induced by radiation, probably resulting from grinding stresses, appeared to constitute about 10 percent of the natural-TL light output; no correction was made. The samples were not heated in a nitrogen atmosphere to reduce this TL not induced by radiation (*3*).

All sherds were from the Casma Valley. The ages of the pottery samples are derived from published reports on the area (*5*) and from sherd assignment by the archeologic workers. The archeologic dates are based chiefly on considerations of stratigraphy and on one C^{14} date (*6*).

The TL_{max}/S values for samples of the pottery series (Table 1) are plotted versus age in Fig. 2. Table 1 shows that there is a standard deviation of around 30 percent for the TL_{max}/S of samples from the same time period. Despite this scattering, the means for the samples from the same time period show a high degree of correlation ($r = .99$ for $n = 5$) (*7*) with the archeologic age, and even the correlation between the values for individual sherds and age is high ($r = .79$ for $n = 22$).

These limited data indicate that the ratio of natural TL to sensitivity is a fairly accurate indicator of archeologic age, especially when averaging is used to obtain a better mean for sherds from the same time level. Part of the variation within samples from the same time period in this series may reflect the omission of radioactivity determinations, but Aitken *et al.* (*3*) found similar variations even when account was taken of radioactivity. The close association between age and the TL indicator of age in our work therefore may result from the relatively arid location of these sherds, as well as from the averaging procedure.

Many factors affect the nature and extent of thermoluminescence, and experimental control of all of them is impractical. Our results suggest that averaging techniques may be effective in dealing with these factors; they further indicate the potential usefulness of thermoluminescence dating in archeology.

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6. The C^{14} dates on Cahuacucho and Gualaño shells indicate an apparent instance of reversed stratigraphy, which makes the dates unacceptable to the archeologist in charge.
7. A TL_{max}/S of 5.35, determined on one Middle Jomon sherd of the Nakano type from Shikimu Town, Hokkaido, indicates substantial age. The estimated age, derived from the regression of archeologic age on TL_{max}/S of the grouped data depicted in Fig. 2, is 7192 years. The archeologic age of the sample is given as around 7000 years.
8. We thank J. R. Cameron for extensive aid. Donald Collier (Chicago Natural History Museum) and Donald Thompson (University of Wisconsin) supplied the Casma sherds. One of us (R.B.M.) benefited from the graduate fellowship programs of NSF and NIH.

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Intermuscular Bones in Pholidophorus bechei from the Lower Lias of England

Abstract. *Intermuscular bones, considered the one neomorph which decisively separates the pholidophoroids from the teleosts, have been found in a specimen of* Pholidophorus bechei *Agassiz, from the Lower Lias of England. It is suggested that intermuscular bones were prevalent among the pholidophoroids.*

The teleost fishes have been characterized as incorporating several improvements in the locomotor mechanism which distinguish them from their presumed ancestors, the Mesozoic Pholidophoriformes (*1*). Among these improvements, none has been regarded as more consistent or more decisive than the origin of intermuscular bones among

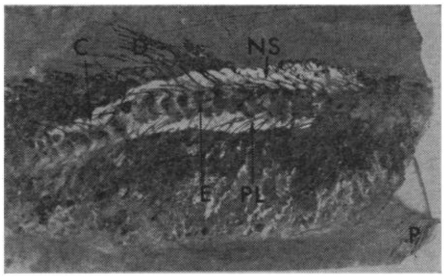

Fig. 1. Abdominal and anterior caudal region of *Pholidophorus bechei* (AMNH No. 6300). Abbreviations: *C*, first caudal vertebra; *D*, dorsal fin; *E*, epineuralia; *NS*, neural spine; *PL*, pleural rib; *P*, pectoral fin.

the leptolepid teleosts and their presence in all of the more generalized teleosts (*2, 3*). Among the pholidophoroids, intermuscular bones have been reported previously only in *Oligopleurus* (*4*) and have been little noted.

A remarkably well-preserved specimen of *Pholidophorus bechei* (the type species of the genus) shows a well-developed series of epineural intermuscular bones extending from the anterior end of the trunk to the last abdominal vertebra (Fig. 1) (*5*). The soft tissues of the head and body were either encased or replaced by calcite before much postmortem compression could take place. As a result, the elements of the axial skeleton retain practically their original spatial relationships. After removal of the scale covering from both sides of the body with an Air-Brasive machine (*6*), the specimen was submerged in xylene to render the calcite virtually transparent.

The epineuralia are very slender, delicate bones, about 5 mm in length in a fish of 140 mm standard length (*7*). Anteriorly, the elements attach near the bases of the neural arches and extend outward, backward, and downward for about three segments. Posteriorly, the epineurals attach higher on the arches and are slightly shorter. A neural spine, neural arch, and epineural form an osseous unit which is paired in each segment and free from the dorsal hemicentrum in each segment of the abdominal region (Fig. 2). In view of possible damage to the specimen, I deemed it unwise to uncover the most anterior vertebrae. No traces have been observed of either epicentralia or epipleuralia.

The Leptolepidae have been excluded from the Pholidophoriformes chiefly on the basis of the intermuscular bones (*3, 4*). In the light of the evidence presented above, it may be assumed that intermuscular bones were common among the Pholidophoriformes, but that few specimens have been preserved or prepared in a manner suitable for revealing them. In view of the presence of intermuscular bones among the pholidophoroids, the closely similar Leptolepidae can no longer be reasonably excluded from the Pholidophoriformes.

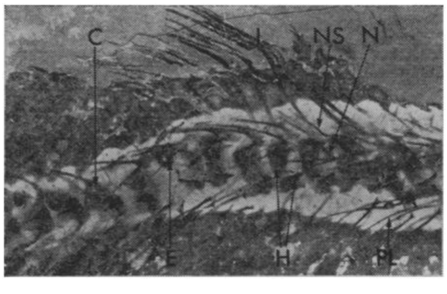

Fig. 2. *Pholidophorus bechei* (AMNH No. 6300). Region of abdominal-caudal transition. Abbreviations: *C*, first caudal vertebra; *E*, epineuralia; *H*, hemicentra; *I*, interneural; *NS*, neural spine; *N*, neural arch; *PL*, pleural rib.

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24 January 1966

Chimeric Mice with Donor-Type Liver Cells

Abstract. *C_3H mice, made chimeric by lethal x-irradiation followed by injection of $(C_3H \times T_6)F_1$ spleen cells, were later stimulated by CCl_4 to produce a vigorous burst of hepatic parenchymal cell mitoses. Cytogenetic studies of the regenerating livers of 11 chimeras identified 89 percent of the cells as donor type by the presence of the distinctive T_6 marker.*

Reports are increasing that mammalian cell systems may take up nuclear material such as nucleosides (*1*), DNA (*2*), and even chromosomes (*3*). Work in our laboratory and in others has suggested that this process in vivo requires circulating trephocytes (nursing cells) to transport the essential nuclear material to the needy cells (*4*), as opposed to total dependence on the extraction of building blocks from noncellular, circulating sources. To test these two concepts we selected as our experimental model the chimeras formed by the injections of massive numbers of $(C_3H \times T_6)F_1$ spleen cells into newborn and weanling, lethally irradiated, C_3H mice. This treatment schedule is known to allow replacement of host hematopoietic tissues, giving rise to the persistent circulation of donor red and white blood cells (*5*). Determinations of whether the liver cells were of host or donor type were based on the results of chromosome preparations made during the peak of regenerative activity of the parenchymal cells, which followed carbon tetrachloride (CCl_4) necrosis. This is a preliminary report of identification of the distinctive T_6 marker in these preparations which indicates donor-type cells.

A total of 54 male and female C_3H mice (*6*) were made chimeric by x-irradiation and injection with F_1 spleen cells (Table 1); F_1 animals were used as donors to minimize graft-versus-host reactions and to take advantage of the close genetic relation to parent strains. Of the 24 animals that survived these treatments, 18 had metaphases numerically and technically suitable for study; the results of these studies of liver chromosomes also appear in Table 1.

The x-irradiation was a single, total-body dose in a compartmented lucite container, with full back scatter (*7*). The air dosages of 606 and 680 r were contrived to give calculated tissue dosages of 900 r to group I and 950 r to groups II and III, respectively. Puramycin (*8*), in a dosage of 15 ml per 4000 ml of drinking water, was given to groups II and III 5 days before and 14 days after irradiation.

The cells for injection were prepared, from pooled spleens from male and female donors, in Ringer's lactate solution and a few drops of heparin (Lipo-Heparin, Riker) with a ground-glass homogenizer. The intravenous injections were made immediately after irradiation; the intraperitoneal, in one or two doses within 24 hours. The booster doses of donor spleen cells given to the animals of group IIa, were injected intraperitoneally immediately after 2-minute exposure of the mice to CCl_4 fumes in a closed container. It was postulated that any uptake of nuclear material could be facilitated during the intense mitotic activity that followed such treatment.

Approximately 4 weeks after irradiation and injection of $(C_3H \times A)F_1$ spleen cells, the control animals of group III were grafted with skin from $(C_3H \times A)F_1$ donors. The grafts all appeared healthy when the mice were killed, showing that reversion of the chimeric state had not occurred, despite the greater age of these animals and their