Dentition of Chilean Paleo-Indians and Peopling of the Americas

Abstract. *Teeth of 12 cremated paleo-Indians (11,000 years old) from caves in southern Chile have crown and root morphology like that of recent American Indians and north Asians, but unlike that of Europeans. This finding supports the view that American Indians originated in northeast Asia. This dental series also suggests that paleo-Indians could easily have been ancestral to most living Indians, that very little dental evolution has occurred, and that the founding paleo-Indian population was small, genetically homogeneous, and arrived late in the Pleistocene.*

The first Americans were small bands of hunting families adapted to the Arctic steppe who had ranged eastward from Siberia across the Beringian plain, the Bering Land Bridge, in search of mammoth and other late Pleistocene big game animals (*1*). The material culture and economy of these paleo-Indians are better known than are their population biology characteristics. This is because most of the few authenticated paleo-Indian skeletons are very incomplete and singular finds. One exception is our small, fragmented and cremated series of 11 paleo-Indians with usable dentitions from cave burials in southern Chile (*2*). Twenty erupted and loose unerupted teeth and 64 observable tooth sockets of these paleo-Indians are the basis for our reconstruction of the peopling of the Americas.

In 1936, one of us (J.B.) discovered the cremation burials in the dry interiors of Cerro Sota and Palli Aike lava caves near the Strait of Magellan, south Chile (about 52°S and 70°W). Cerro Sota Cave, a narrow, 15-m-long, horizontal hole, is poorly suited for human habitation but yielded enough cultural material to relate to items found in Fell's Cave, 30 km distant, which has a long record of human occupation beginning before the extinction of the native horse (*Parahipparium saldasi*) and the ground sloth (*Mylodon listai*). Radiocarbon measurements of charcoal from fire hearths associated with these extinct fauna and paleo-Indian artifacts indicate an age of 11,000 years (*3*, *4*).

At the rear of Cerro Sota Cave, 1 m below the modern surface, was a group cremation grave of three old women, each with many teeth missing before death, two children, and two infants. The simultaneous deaths of these seven persons can be correlated with a rockfall that occurred in Fell's Cave, where slabs of sandstone, which dropped from the ceiling, were found resting on the surface of period 1 debris. If the relatives of the infants and old women were engaged in activity outside Cerro Sota, it would explain the odd demographic character of the cremation. The skeletons were so badly burned and broken that antemortem injuries cannot be recognized.

Palli Aike Cave, in the remnant wall of an old volcano, was well suited for habitation although permanent nearby water was lacking. It yielded the same cultural record as Fell's Cave (*4*). On a floor of lava rock and ash in Palli Aike were period 1 artifacts and shallow fire hearths, in and around which were bones of horse, sloth, and guanaco. Also on this surface were remains of three cremations. The remains had lain exposed until they became scattered, disoriented, and incomplete to a degree that suggested later people had cleared most of the bone from the cave. Teeth of five people (two adults, an adolescent, and two 4- to 10-year-old children) can be recognized.

As the amount of period 1 debris was minimal in Palli Aike Cave, and as it was not separated from later material by a traceable stratum, there is the possibility that the cremations belong to the beginning of period 2. It is equally possible that the small amount of period 1 occupational debris was due to the use of the cave primarily for disposal of the dead. In either case, the age for the human remains should be close to the 11,000-year-old date applicable to the time of extinction of the large game animals (*4*).

As a result of the odontological studies by Hrdlička (*5*), Nelson (*6*), and Dahlberg (*7*), some idea about the nature of recent American Indian dental morphology has been developed. With minor exceptions, the teeth of American Indians seem more like those of Asians than those of Europeans. American Indians, Aleut-Eskimos, and Asians, in contrast with Europeans, possess substantially higher frequencies of incisor shoveling, incisor double-shoveling, lower molar deflecting wrinkles, sixth cusps on the lower molars, single-rooted upper first premolars and lower second molars, three-rooted lower first molars, and enamel extensions on the lingual root surfaces (*5–7*, *8*). Europeans possess higher frequencies of Carabelli's cusp, four-cusped lower molars, and two-rooted canines, along with other features (*9*), all of which are believed to have high genetic components in their occurrence and expression (*10*).

The discovery of these Chilean teeth

Table 1. Frequencies of key dental traits in the Chilean paleo-Indians, North and South American Indians, north Asians, and Europeans (mainly individual counts with sexes pooled). Indian samples include recent and skeletal teeth with the majority from western North America; north Asians include Shang Dynasty An-yang Chinese and recent Mongols, Japanese, and a few northeast Siberians; Europeans include American whites, and various teeth from living and recent samples from England, Ireland, France, Germany, Poland, Netherlands, Denmark, Finland, and minor numbers from elsewhere in Europe where counting methods match those of Turner (*7*, *9*).

Trait*	Chilean paleo-Indians	North and South American Indians	North Asians	Europeans
Shoveling $\mathrm{I}\underline{1}$	100.0 (2/2)†	100.0 (115/115)	100.0 (236/236)	31.8 (2511/7885)
Double-shoveling $\mathrm{I}\underline{1}$	100.0 (2/2)	58.0 (94/162)	34.1 (70/205)	14.3 (3/21)
Tuberculum dentale $\mathrm{I}\underline{1}$	100.0 (2/2)	66.4 (543/818)	65.7 (67/102)	63.6 (98/154)
Cusp 5 $\mathrm{M}\underline{1}$	50.0 (1/2)	19.6 (30/153)	32.9 (71/216)	14.7 (22/150)
Carabelli's trait $\mathrm{M}\underline{1}$	100.0 (2/2)	55.9 (133/238)	43.3 (117/270)	81.1 (189/233)
Y groove pattern $\mathrm{M}\overline{2}$	0.0 (0/2)	7.0 (22/313)	5.2 (13/252)	13.9 (165/1186)
Four-cusped $\mathrm{M}\overline{2}$	0.0 (0/2)	11.0 (49/446)	13.8 (24/174)	86.9 (146/168)
Single-rooted $\mathrm{P}\underline{1}$	100.0 (4/4)	87.9 (507/577)	73.4 (193/263)	53.4 (2276/4264)
Three-rooted $\mathrm{M}\overline{1}$	33.3 (1/3)	7.2 (166/2308)	37.2 (106/285)	1.4 (93/6598)
Single-rooted $\mathrm{M}\overline{2}$	0.0 (0/2)	33.9 (121/357)	30.9 (78/252)	14.6 (635/4354)
Mandibular torus	28.6 (2/7)	25.8 (67/260)	36.9 (113/306)	5.4 (306/5670)

*Trait scoring is based on complete absence of expression versus any degree of occurrence (*11*). Minor numbers of Europeans had been counted by teeth rather than by individuals. $\mathrm{I}\underline{1}$ denotes upper central incisor; $\mathrm{M}\underline{1}$, upper first molar; $\mathrm{M}\overline{1}$, lower first molar; $\mathrm{M}\overline{2}$, lower second molar; $\mathrm{P}\underline{1}$ upper first premolar. †Numbers in parentheses are sample size.

Table 2. Mean measure of distance between Chilean paleo-Indians, American Indians, north Asians and Europeans. Values are based on those of Table 1.

Statistic	Paleo-Indian and Indian	Paleo-Indian and north Asian	Paleo-Indian and European	Indian and north Asian	Indian and European	North Asian and European
Mean measure of distance	−0.0366	0.0475	0.7151*	0.0999*	0.7949*	0.8494*
Standard deviation	0.1553	0.1557	0.1568	0.0037	0.0073	0.0074
Effective divergence	−0.0478	0.0162	0.6624	0.1448	0.3966	0.9335
Maximum value	0.5177	0.5167	0.5186	0.9887	0.9955	0.9912
Standard effective divergence	−0.0924	0.0314	1.2773	0.1464	0.3984	0.9418
Significance (11 d.f.)	9.3861	11.7386	34.3649	223.0083	1450.5602	1756.4339

*Mean measure of distance is significant.

makes it possible to estimate the frequencies of paleo-Indian dental characteristics in a skeletal population context, on the basis of new and previously established observation procedures and criteria (*11*).

There are indications that incisor shoveling and double-shoveling were probably common, as were the deflecting wrinkle, single-rooted upper first premolars, and three-rooted lower first molars. In fact, Palli Aike specimen 774 has the oldest three-rooted lower first molar known from the Americas as well as from Asia and Europe. The mutation for this alternative to the more common double-rooted molar must be at least 11,000 years old.

Comparisons of dental traits of the southern Chile paleo-Indians, living and recent American Indians, and eastern Asians show all to be remarkably similar (Table 1). Very little dental microevolution is suggested in the Americas for the past 11,000 years.

We compared 11 traits for which data are available. In Table 1, the traits and their frequencies are shown, with absence equaling total lack of expression and presence equaling any degree of expression; this dichotomization is acceptable for such a broad areal comparison but is not recommended for intraregional dental comparisons (*12*). Values of the mean measure of distance and associated statistics (Table 2) seem to be concordant with the univariate comparisons and agree well with interpretations of north Asian–American prehistory (*13*, *14*).

Since a smaller mean measure of distance indicates a closer overall resemblance in dentition, interpretation of Table 2 indicates that paleo-Indian and later Indian teeth are very similar, as are paleo-Indian and north Asian teeth. Later American Indian and north Asian teeth are somewhat less similar, as might be expected given twice the generational time between them for possible microevolutionary divergence. Consistent with interpretations of Eurasian population biology and history (*14*), paleo-Indian and later Indian teeth are very unlike those of Europeans, but modern north Asian teeth are even less similar to those of Europeans than are paleo-Indian teeth. The significance of this last fact is uncertain; perhaps it is nothing more than the result of computations based on a small series. Until other paleo-Indian series are discovered, it may be viewed as a clue to the more precise region in Eurasia wherein paleo-Indians originated.

Certainly the late Pleistocene and Holocene population of Eurasia was not homogeneous. In addition to the strongly contrasting dental patterns that evolved between Europe and Asia, the Mongoloid dental complex (*15*) has been found to contain two subpatterns, according to analysis of teeth from southeastern and northern Asia (*16*). In north Asia a pattern of trait intensification and addition, called Sinodonty, occurs in Chinese, Japanese, Mongols, and northeast Siberians. In southeastern Asia, the dental pattern is one of simplification or retention and is termed Sundadonty. It is found in Indonesians, Javanese, aboriginal Taiwan Atayals, and throughout island southeast Asia as well as in central Japan Jomonese predating 200 B.C., but not afterward except in Ainus. So far, no American Indian dental series—skeletal, living, or paleo-Indian—shows any sign of the Sundadont pattern. Only Minnesota Lady evidences some divergence away from central Sinodonty. Otherwise, all New World peoples studied, both Indians and Aleut-Eskimos, possess the Sinodont dental pattern.

Dental traits, which are under strong genetic control and evolve slowly, provide one of the better means for establishing direct epigenetic relationships among populations over hundreds of generations. This is evidenced in the Cerro Sota and Palli Aike teeth by their close similarity to later American Indian teeth.

These paleo-Indian teeth, together with other facts, provide diachronic evidence that American Indians came from Asia by way of Beringia. Geographic, geological, archeological, and paleontological conditions and facts show that the New World was peopled via Beringia by paleo-Indians who arrived in late Pleistocene times. Although the precise geographic origin and biological affiliation of paleo-Indians has yet to be worked out, the Cerro Sota and Palli Aike dentitions provide a direct and diachronic paleo-Indian link with north Asia.

These Chilean teeth suggest that paleo-Indians were ancestors of the vast majority of past and present American Indians. Because there are no important differences in the Cerro Sota and Palli Aike dentitions and those of living and recent Indians, it is evident that most are descended from the original paleo-Indian migrants from northeast Asia. Furthermore, Indian dental variability, viewed against Eurasian dental variation, suggests that there was only one, or perhaps two, Pleistocene migrations, and those probably by relatively few numbers of individuals and bands. There was probably no other significant immigration until the arrival of the ancestors of today's Arctic Mongoloids, the Aleuts and Eskimos.

C. G. TURNER II
Department of Anthropology, Arizona State University, Tempe 85281
J. BIRD
Department of Anthropology, American Museum of Natural History, New York 10024

References and Notes

1. These points were discussed by participants at a symposium on late Pleistocene and early Holocene Asian-American cultural relationships held during the 43rd International Congress of Americanists, Vancouver, B.C., Canada, 14 August 1979, and at the 14th Pacific Science Congress, Khabarovsk, U.S.S.R., 24 to 25 August 1979.
2. H. L. Shapiro (personal communication) found the reconstructable crania to be dolichocranial and to resemble the Lagoa Santa crania of Brazil. The cranial index of Cerro Soto No. 2 is 71.2. Consistent with this and the archeological interpretation that the Chileans were paleo-Indians and therefore big game hunters, or at least heavy meat eaters, is the fact that the remaining teeth are free of dental caries, and most of the adults show evidence of periodontal disease. Abscessing was severe and common in at least four of the five observable adults. No porotic hyperostosis occurred in the frontal orbits or on the distal parietals of the teeth of the three observable individuals.
3. Relevant radiocarbon dates for Fell's Cave are: layer 20, area D, start of cultural period 1, 11,000 ± 170 years (I-3988); layer 19, area C, period 1, 10,720 ± 300 (W-915); layer 18, period 1 and 2 boundary, area D, 10,800 ± 160 years (I-5146); and layer 12, area D, end of period 2, 8430 ± 135 years (I-5143). These dates are based on the 5568 ± radiocarbon-14 half-life and the 1950 standard. A date of 8639 ± 450

years (C 485) was obtained from Palli Aike Cave charred horse and sloth bones by W. Libby in 1951. This is not in agreement with various other measurements, and the figure should not be used without noting the details of the experimental procedure employed.
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17. We are grateful for assistance from the National Geographic Society and Arizona State University Faculty Research Program that made possible the study of these paleo-Indian and other teeth. We also thank D. K. Patterson for assistance and use of the mean measure of distance program. Our Indian and Asian comparisons are based on physical anthropological collections from the American Museum of Natural History, Smithsonian Institution, Academia Sinica (Taiwan), Field Museum, Lowie Museum, Burke Memorial Washington State Museum, and Arizona State University. We thank I. Tattersall, J. L. Angel, Li Chi, H.-M. Yang, G. Cole, F. Norick, and D. Swindler for enabling study of these materials. We are indebted for supplementary information on Siberian anthropology from S. Arutinov, I. A. Mochanov, G. I. Medvedev, N. N. Dikov, R. S. Vasilievsky, R. Ackerman, R. Carlson, and L. Okladnikova, and for other help and views by V. N. Denishchick and D. M. Hopkins. This report is an expanded version of a paper delivered at the 43rd annual meeting of the Society for American Archaeology, Tucson, Ariz., May 1978. It is the seventh in a series of published papers on the peopling of the Pacific basin and adjoining areas. Full description of these paleo-Indian teeth can be obtained from C.G.T.

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Familial Studies of Intelligence: A Review

Abstract. *A summary of 111 studies identified in a survey of the world literature on familial resemblances in measured intelligence reveals a profile of average correlations consistent with a polygenic mode of inheritance. There is, however, a marked degree of heterogeneity of the correlations within familial groupings, which is not moderated by sex of familial pairing or by type of intelligence test used.*

In 1963, Erlenmeyer-Kimling and Jarvik (*1*) published a summary of the world literature on IQ correlations between relatives. Their finding that the pattern of correlations averaged over independent studies was consistent with the pattern predicted by a polygenic theory of inheritance has been widely cited as strong evidence for some genetic determination of IQ (*2*). Although the accumulation of a great many new data along with the discrediting of Burt's important study on monozygotic twins reared apart (*3*) has outdated that review, the authors' summary or slightly modified versions of it (*4*) continue to be widely reproduced (*5*). Recently Plomin and DeFries (*6*) have reported a comparison of those summary data with the results of several large, recent familial studies of IQ. They conclude that, in general, the recent studies show less resemblance between relatives than do the data reported by Erlenmeyer-Kimling and Jarvik. Their summary is not comprehensive, however, and it does not identify the factors that distinguish the two bodies of data. Roubertoux and Carlier (*7*) have also published a recent review, but it contains only 37 percent of the studies to be cited here.

The purpose of this report is to provide a comprehensive contemporary summary of the world literature on the IQ correlations between relatives. We have updated the 1963 summary, adding recent data and deleting several studies included in the earlier review that do not meet our methodological criteria for inclusion. Although the pattern of averages reported in this and earlier reviews is remarkably consistent with polygenic theory, the individual data points are quite heterogeneous. Therefore, we have also assessed the extent to which the reported correlations are heterogeneous and have attempted to identify some factors that contribute to this heterogeneity.

In our survey of the literature we found 140 studies that reported on familial resemblances in broad cognitive ability. These were reduced to 111 by the application of explicit selection criteria (*8*–*12*). The 111 studies, which include 59 reported in the 17 years subsequent to the Erlenmeyer-Kimling and Jarvik summary, yielded 526 familial correlations, based upon 113,942 pairings. Figure 1 displays the correlations between relatives, biological and adoptive, in the 111 studies. The median correlation in each distribution is indicated by a vertical bar. The small arrow indicates the correlation that would be predicted by a genetic model with no dominance, no assortative mating, and no environmental effects. Researchers do not subscribe to such a simple model, but it provides a noncontroversial pattern against which to compare the results of various familial groupings. Different investigators will undoubtedly fit different models to the data.

In general, the pattern of average correlations in Fig. 1 is consistent with the pattern of correlations predicted on the basis of polygenic inheritance. That is, the higher the proportion of genes two family members have in common the higher the average correlation between their IQ's.

The data set contains considerable heterogeneity, as indicated by the χ^2 statistics. In an attempt to identify the factors contributing to the heterogeneity, we subdivided the familial groupings into opposite-sex and same-sex pairings (Fig. 2) and male and female pairings (Fig. 3). Among dizygotic twins the IQ's of same-sex twins are more similar than those of opposite-sex twins. This may reflect a social-environmental effect (parents may treat same-sex twins more similarly than opposite-sex twins). The difference between nontwin same-sex and opposite-sex siblings and between same-sex and opposite-sex parent-offspring pairings is trivial. The male-female comparison does not yield consistent trends. For example, the average correlations are larger in male twins than in female twins, but the reverse is true for other siblings. The absence of any demonstrable sex effect is consistent with a polygenic theory of inheritance that does not posit the existence of sex linkage. Environmental theories that emphasize the importance of sex-role effects on general cognitive development are not supported by these results (*13*).

Another possible source of heterogeneity is the intelligence test used. There are many tests that purport to measure intelligence, and they may not be highly interrelated. We found great diversity in test selection. For example, the 34 corre-

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