

DENTAL PATHOLOGY OF ABORIGINAL CALIFORNIA

BY

R. W. LEIGH

UNIVERSITY OF CALIFORNIA, PUBLICATIONS IN AMERICAN ARCHAEOLOGY
AND ETHNOLOGY

Volume 23, No. 10, pp. 399-440, plates 60-67

UNIVERSITY OF CALIFORNIA PRESS
BERKELEY, CALIFORNIA

1928

UNIVERSITY OF CALIFORNIA PUBLICATIONS
DEPARTMENT OF ANTHROPOLOGY

The following publications dealing with archaeological and ethnological subjects issued under the direction of the Department of Anthropology are sent in exchange for the publications of anthropological departments and museums, and for journals devoted to general anthropology or to archaeology and ethnology. They are for sale at the prices stated. Exchanges should be directed to THE EXCHANGE DEPARTMENT, UNIVERSITY LIBRARY, BERKELEY, CALIFORNIA, U. S. A. Orders and remittances should be addressed to the UNIVERSITY OF CALIFORNIA PRESS.

Publications of the University of California Press may be obtained from THE CAMBRIDGE UNIVERSITY PRESS, FETTER LANE, LONDON, E. C. 4, ENGLAND, to which orders originating in Great Britain and Ireland should be sent.

AMERICAN ARCHAEOLOGY AND ETHNOLOGY.—A. L. Kroeber and Robert H. Lowie, Editors. Prices, Volume 1, \$4.25; Volumes 2 to 11, inclusive, \$3.50 each; from Volume 12 on, \$5.00 each. Volumes 24, 25, and 26 in progress.

	Cited as Univ. Calif. Publ. Am. Arch. Ethn.	Price
Volume 1.	378 pages. 1903-1904	\$4.25
Volume 2.	392 pages, 21 plates. 1904-1907	3.50
Volume 3.	344 pages. 1905	3.50
Volume 4.	374 pages, 10 plates, 1 map. 1906-1907	3.50
Volume 5.	384 pages, 25 plates. 1907-1910	3.50
Volume 6.	400 pages, 3 maps. 1909	3.50
Volume 7.	443 pages, 50 plates. 1907-1910	3.50
Volume 8.	369 pages, 28 plates. 1908-1910	3.50
Volume 9.	439 pages, 1 map. 1910-1911	3.50
Volume 10.	385 pages, 41 plates. 1911-1914	3.50
Volume 11.	479 pages, 45 plates. 1912-1916	3.50
Vol. 12.	1. Composition of California Shellmounds, by Edward Winslow Gifford. Pp. 1-29. February, 1916 .....	.30
	2. California Place Names of Indian Origin, by A. L. Kroeber. Pp. 31-69. June, 1916 .....	.40
	3. Arapaño Dialects, by A. L. Kroeber. Pp. 71-138. June, 1916 .....	.70
	4. Miwok Moieties, by Edward Winslow Gifford. Pp. 139-194. June, 1916 .....	.55
	5. On Plotting the Inflections of the Voice, by Cornelius B. Bradley. Pp. 195-218, plates 1-5. October, 1916 .....	.25
	6. Tübatulabal and Kawaiisu Kinship Terms, by Edward Winslow Gifford. Pp. 219-248. February, 1917 .....	.30
	7. Bandler's Contribution to the Study of Ancient Mexican Social Organization, by T. T. Waterman. Pp. 249-282. February, 1917 .....	.35
	8. Miwok Myths, by Edward Winslow Gifford. Pp. 283-338, plate 6. May, 1917 .....	.55
	9. California Kinship Systems, A. L. Kroeber. Pp. 339-396. May, 1917 .....	.60
	10. Ceremonies of the Pomo Indians, by S. A. Barrett. Pp. 397-441, 8 text figures. July, 1917 .....	.45
	11. Pomo Bear Doctors, by S. A. Barrett. Pp. 443-465, plate 7. July, 1917 .....	.35
	Index, pp. 467-473.	
Vol. 13.	1. The Position of Yana in the Hokan Stock, by E. Sapir. Pp. 1-34. July, 1917 .....	.35
	2. The Yana Indians, by T. T. Waterman. Pp. 35-102, plates 1-20. February, 1918 .....	.75
	3. Yahi Archery, by Saxton T. Pope. Pp. 103-152, plates 21-37. March, 1918 .....	.75
	4. Yana Terms of Relationship, by Edward Sapir. Pp. 153-173. March, 1918 .....	.25
	5. The Medical History of Ishi, by Saxton T. Pope. Pp. 175-213, plates 38-44, 8 figures in text. May, 1920 .....	.45
	6. The Fundamental Elements of Northern Yana, by Edward Sapir. Pp. 215-234. April, 1922 .....	.30
	7. Functional Families of the Patwin, by W. C. McKern. Pp. 235-258. April, 1922 .....	.35
	8. Elements of Culture in Native California, by A. L. Kroeber. Pp. 259-323, with 4 maps. November, 1922	1.00
	9. A Study of Bows and Arrows, by Saxton T. Pope. Pp. 329-414, plates 45-64. August, 1923	1.75
	Index, pp. 415-426.	

DENTAL PATHOLOGY OF ABORIGINAL
CALIFORNIA

BY
R. W. LEIGH

UNIVERSITY OF CALIFORNIA PUBLICATIONS IN AMERICAN ARCHAEOLOGY
AND ETHNOLOGY

Volume 23, No. 10, pp. 399-440, plates 60-67

Issued December 29, 1928

UNIVERSITY OF CALIFORNIA PRESS
BERKELEY, CALIFORNIA

CAMBRIDGE UNIVERSITY PRESS
LONDON, ENGLAND

DENTAL PATHOLOGY OF ABORIGINAL CALIFORNIA

BY
R. W. LEIGH

CONTENTS		PAGE
Introduction.....		399
The California food complex.....		400
Racial and developmental dental peculiarities.....		405
Attrition.....		408
Caries.....		412
Periapical osteitis and other paradental osseous lesions.....		415
Periodontoclasia.....		418
Summary.....		422
Specimen numbers.....		424
Bibliography.....		424

PLATES
(Following page 425.)
60-67. Dental pathology.

INTRODUCTION

Physical anthropology rightfully embraces the study of racial pathology; this study essays a subdivision thereof, based on examination of three hundred crania of California Indians in the University of California Museum of Anthropology. General characteristics of racial dentition and variation in susceptibility to lesions of the teeth and paradental tissues, correlated with food habits and general mode of life, are of interest from many points of view. Examination of the available material was made possible through the invitation of Professor A. L. Kroeber and the courtesy of the curator, Mr. E. W. Gifford, in placing the facilities of the Museum at my disposal. For the notes on the California food complex, the writer has drawn liberally and literally from Professor Kroeber's Handbook of the Indians of California, a virile and authoritative source. The specimens have come from pre-Spanish or early post-Spanish epochs, but before the food habits of the aborigines had been materially influenced by Caucasian contact. Of the some fifty tribes whose domains were within the present state, not more than a dozen are represented in the

specimens examined. The manner of disposal of the dead varied in different localities, and possibly in different epochs; obviously tribes which practiced cremation are not represented in the collections.

Since the important determinants of dental conditions are the habitat, food complex, mode of life, and general culture of peoples, rather than language or origin, the following grouping of the crania has been adopted:

<i>Source</i>	<i>Crania</i>
Santa Barbara islands and mainland.....	138
San Francisco bay and central coast.....	104
The Great Valley.....	50
The Nevada slope of the Sierra.....	8
	<hr/>
Total crania examined.....	300

The first group belongs to the southern California culture province, which extends southward from the Tehachapi range in the interior and Point Concepcion on the coast to the Mexican boundary. The Indians of this area may be divided into two groups: (*a*) those of the channel islands, coast, and mountains; and (*b*) those of the Colorado River basin. The latter, however, are not represented in this study as they practiced cremation rigidly; in this group are the Mohave, who were agriculturists, and it is to be regretted that some of their crania could not be compared with those of other tribes who subsisted on what their natural habitat afforded. The other groups listed belong to the central California culture province, excepting the eight from the margin of the Great Basin. Central California alone has developed a well defined indigenous culture; this area is the seat of old stabilized tribes and mode of life with few intrusions: a peculiarly close adaptation to their habitat existed.

THE CALIFORNIA FOOD COMPLEX

Food complexes are developed in various geographical areas; man specializes in certain foods which become the staples, or chief articles, to which are added auxiliary articles. The California Indians were not agriculturists, had little if any commerce, but subsisted exclusively on the edible fauna and flora of their native habitat. They are, perhaps, the most omnivorous group of tribes on the American continent. These aborigines secured their variety of foods by techniques that were closely interrelated, or, where diverse, connected by innumerable transitions. The acorn was the predominant staple; this

was the chief daily food of more than three-fourths of native California. Plants appear to have furnished a larger part of the diet than animals in almost all parts of California. Fish and mollusks, in regions stocked with them, were consumed in larger quantities than flesh, especially in the regions of the salmon-carrying rivers of northern California, the Santa Barbara archipelago, Clear and Klamath lakes, San Francisco bay, and the coast. Not many acorns were accessible to the inhabitants of the Santa Barbara islands and coast, where fish and mollusks formed the basis of subsistence. As for game, the rodents, from jackrabbits to gophers, together with birds, evidently furnished more food the seasons through than deer and other ruminants. Insects and their larvae were utilized when they could be gathered in worth while masses. On the deserts, snakes and lizards, and even the coyote, which was elsewhere taboo, were eaten by many groups. The food supply, largely through variety, was reasonably adequate. An incomplete list for the Salinan Indians includes: every obtainable variety of fish, reptiles, birds, and mammals, with the single exception of the skunk, and possibly the dog and coyote; their vegetable dietary contains six kinds of acorns, three of grasses, three of clover, six at least of berries, and two of pine nuts, besides wild oats, buckeye, sunflower, chia and sages, grapes, prickly pears, yucca, and Brodiaea bulbs. This wealth of plant foods is typical of aboriginal California.

Differences in the diet of tribes living in the four areas listed above, and dominant local staples, are mainly as follows. The ancestors or predecessors of the late Chumash and Gabrielino of the Santa Barbara islands and mainland subsisted largely on the molluskan fauna and fish of their waters. Sea lions, stranded whales, and occasionally mountain sheep served as auxiliaries. Practically all mammals, birds, and reptiles were deemed edible. The ratio of plant to animal food was probably smaller than that of the other groups. Acorns were only accessible in the highlands which these Indians infrequently visited; but all seeds and edible roots of the soil to which they tenaciously limited themselves were utilized. In the preparation of food in this region, the movable stone mortar was used from prehistoric to modern times. The Gabrielino were imbued with a strong conviction that every nation had its own peculiar food and for one to partake of the characteristic nourishment of the other, in the very nature of things, was to bring sickness. That the food supply was ample in this region and that the equable climate and calm waters somewhat reduced the struggle for existence, as compared with that

of other localities, is attested by the advanced material culture among the Chumash: they were finished artisans and possessed many objects of art and ceremony. They were of maritime inclination; and were held to be a superior native people by the Spanish and later by the Americans.

Tribes that lived on San Francisco bay and central coasts also subsisted to a large extent, especially during the winter months, on mollusks, particularly mussels, as is evidenced by the shell deposits on bay and ocean frontage. However, they had considerable salmon during high water, and also prized the lamprey eel; sea lions were occasionally slaughtered, and very infrequently whales. A goodly supply of acorns and seeds was not far distant in the autumn, and short seasonal migrations were habitual. Seaweeds replaced salt. The shellmounds show that

the natives of the San Francisco Bay region two or three thousand years ago ate the same food, in nearly the same proportions (only mammalian bones became more abundant in higher levels), prepared it in substantially the same manner, as their recent descendants. The basis of culture remained identical during the whole of the shellmound period.

The same molluskan fauna consumed by these aborigines is available in the local market today. With such a stabilized food complex over a period of three thousand years, both the inherited or congenital characteristics of the dentition, as well as acquired pathological conditions in the specimens at hand, are of cogent significance. Physical anthropology here presents a reliable and immutable dietary experiment; and comparative human dental pathology, within the limits of the available material, provides data of premier importance.

The ratio of plant to animal food in the diet of the tribes of the Great Valley is higher than that of the coast people. The acorn is the predominant staple; but many seeds and roots, as well as fish and mammals, from deer to gophers, are included in the omnivorous diet of the valley people.

The Nevada slope of the Sierra below 7500 feet is covered with the nut pine, *Pinus monophylla*, down to the sage plains. Its nuts, even to this day, are gathered in enormous amounts by the Indians for food. The nuts are separated from the cones by roasting. In Nevada the pine nut, rather than the acorn, is the staple; and various seeds and bulbs supplement it. The jackrabbit, rodents, and reptiles constitute the larger part of the animal food. Deer and antelope infrequently serve as big game. This is a marginal habitat of the Great Basin, into which the central California culture province merged.

In the greater part of California, acorns constituted a larger part of the diet than any other food. The acorn most esteemed was that of the tan oak, *Quercus densiflora*, but those of other species, such as the black oak, *Quercus californica*, were utilized. Acorn meal is about as tasteless as wheat flour cooked in water would be, nearly as nourishing, but richer in starch, and, when prepared from certain species, perceptibly oily. In relation to the dentition, the technique of preparation of food is second in importance only to the food itself. A lengthy though simple technique of gathering, hulling, drying, grinding, sifting, leaching, and cooking had been devised. Many other fruits and seeds were treated similarly. These were whipped by seed-beaters into close-woven or glue-smearred conical baskets; then parched with coals in shallow baskets, winnowed, ground, and eaten either dry or, like acorn meal, as boiled gruel or lumps of unleavened bread baked by the open fire. The acorn meal technique dominated the preparation of all other plant and even animal foods: the grinding process was universal. The pounding of flesh is a habit common to most of the California Indians. Salmon after being smoked was often pulverized. Salmon bones and deer bones, as well as those of the rabbit, especially the vertebrae, were crushed and stored; to be made into soup in winter, or eaten at once raw or baked. Manzanita berries were crushed, but California was essentially a land of seeds rather than berries. Even in acornless sections the natives used a small mortar for fresh or dried meat and fish, and old edentulous persons possessed small mortars for their personal use, such as the grinding of whole small rodents given them by their young relatives. These practices, it is likely, had a wide distribution in California. Other processes of the acorn and seed preparation complex were extended to various other foods: leaching to wild plums, parching to grasshoppers and caterpillars. This acorn and small-seed food complex is peculiar to California, and clearly dominates the food habits. Where the acorn fails, other foods are treated similarly; the mesquite bean in the southern desert; the piñon nut east of the Sierras; the water lily in Klamath-Modoc lakes.

The technique of preparing the flour and subsequently cooking it, through the introduction of extraneous abrasives, apparently has deleteriously affected the teeth of aboriginal California. Pulverization was either by pounding in a mortar or rubbing on the undressed metate or oval grinding slab. The grinding process had become a well established cultural pattern. The mortar was a pit in an outcrop

of granite, in a boulder, or in lava, and in the south often in sandstone. The metate and grinding slab were usually of basalt, lava, or porphyry. Through constant use, the pits would be worn so deep as to become useless, when shallow ones would again be sought. The pestles were often nothing more than longish river boulders; but with some tribes they were more definitely shaped. The scattered meal was swept together with fibrous plants.

Raw acorns are not palatable as they contain much tannic acid; this necessitated leaching the pounded meal with hot water. The technique of leaching varied somewhat in different sections: in the north the meal was spread directly into a shallow hole formed in the sand; in central California fir leaves were interposed; in the south an open-work basket was used. Any of these devices permitted the hot water to be drained off. The water was heated in small, close-woven baskets by means of hot stones placed in them.

Acorn meal was boiled similarly, with hot stones in small baskets. In boiling, the hot stones must be stirred to insure equal cooking of the contents and to prevent holes being burned through the containing basket. A little paddle was used for this purpose. Small, shallow cook pots of soft stone, perhaps steatite, were used by some tribes, notably the Gabrielino of Santa Catalina island; these pots were dug out with quartz. Hot stones were placed in them also for cooking the gruel. Broken soapstone pots were used for baking slabs. The Gabrielino also possessed ornamental vessels of fine sandstone, which probably were of ceremonial rather than utilitarian significance. A variant of cooking the usual acorn gruel was to bake unleavened cakes in the sand or by the open fire; these cakes were extremely hard. A stone-lined, covered pit in the earth was used for cooking stalks of edible plants. The pulverization, leaching, and cooking methods of aboriginal California here outlined made inevitable the introduction of extraneous abrasives into the acorn and seed flour, as well as into other foods subjected to these typical techniques.

Closely related to the diet of a people is the use of tobacco, and sometimes of other habit-forming narcotics. This custom is of especial significance in a study of the dentition. Kroeber is authority for the following:

The Californians were light smokers, rarely passionate. The pipe is found everywhere, and with insignificant exceptions is tubular. The plant was grown by some of the northern groups. Incidentally, this is an example of limited agriculture restricted to a people of a small area remote from tribes with farming customs. Tobacco, of two or more species of *Nicotiana*, was smoked everywhere,

but by the Yokuts, Tubatulabal, Kitanemuk, and Costanoans it was also mixed with shell lime and eaten. Garcés mentions the eating of tobacco by the Kitane-muk. The leaves were brayed with a white stone (lime) and water in a small mortar, and the end of the pestle licked off.

Concoctions were frequently swallowed, and the available species of *Nicotiana* proved potent emetics. The avowed purpose of the practice was for the relief of fatigue before sleep. This practice was more common than habitual chewing. And with reference to the Yokuts, Kroeber writes: "the abortiveness of their pipe is to be found in the fact that a common practice of all tribes was to eat tobacco instead of smoking it. One method was to mix the leaves with fresh-water mussel shells that had been burned to lime." Through contact with the Yokuts, the Salinans became addicted to the same practice. The eating of tobacco mixed with shells in California is analogous to the chewing of coca leaves mixed with lime by South American Indians, and the chewing of betel nut mixed with lime by various Orientals. The habitual eating of tobacco, especially when mixed with such abrasives as lime and mussel shells, produces rapid attrition of the teeth. The habitual use of tobacco as an emetic would also be deleterious to the teeth in that it produces a decalcifying acidic pabulum about the teeth.

RACIAL AND DEVELOPMENTAL DENTAL PECULIARITIES

Close examination in good light was made of all skulls. A fine explorer and calipers were the only instruments used. Data were recorded on a form which provides an appropriate notation for the thirty-two teeth in the series, and a short symbol for each pathologic process made possible accurate and rapid recording. All observable lesions in the teeth, as well as in the paradental bone, were noted. Due to the conical shape of the roots of the superior incisors, not a few had been lost post-mortem, but in all cases the alveoli were carefully examined. Peculiar anatomical and morphological characters were noted. The age, estimated within a decade, and sex were observed in each case. Age is determined by the extent of cranial synostosis, degree of attrition of the teeth, amount of resorption of the alveolar process, and, in senile specimens, by a generalized diminution of lime salts in the vault. Sex, in several of these crania, is problematical: masculine characteristics in males with small skulls are not well developed, or there is a close approach to masculine characteristics in some females. Most of the dental lesions are classifiable under the following pathologic processes: (a) developmental—maloc-

clusion and aberrant eruption, supernumerary and atypical teeth, hypoplasia; and (b) acquired—attrition and abrasion, dental caries, periapical abscess, osteitis, periodontoclasia and exfoliation, extraneous deposits.

The palate and arches in the majority of specimens are fairly short and elliptical in form, some are parabolical, and in not a few the arch is severely U-shaped. In size the teeth are average or smaller, with the exception of the superior lateral incisors which are frequently broad. The superior incisors are characterized by prominent marginal ridges; and, as shown by Hrdlička, this is a racial characteristic of the American Indian. Observation of this distinctive form must be sought in children or sub-adults, as the teeth of older persons are too badly worn. In some skulls there is a streaming of the enamel into the bifurcation of the roots with occasional detached enamel pearls: nos. 2802 and 1737 exemplify this feature. This root-wise extension of the enamel is conspicuous in the teeth of the Sioux, Eskimo, and Polynesians. Congenital bilateral diastemata, probably of phylogenetic significance, existed in some crania, such as no. 2181, distal to the inferior cuspid, in others distal to the superior lateral incisor.

Normal mesiodistal relationship of the superior and inferior arches, as determined by the first molars, is the rule in these crania. However, in thirty-three skulls, or 11 per cent, one or more teeth are not in harmony with the line of occlusion, class 1 malocclusion (Angle). This number includes impactions of seven lower third molars and three upper cuspids. No. 276 has an impacted upper cuspid in which the apex is pointed upward and lateral to floor of naris, the apex being through the cortical plate, and there is retention of the deciduous cuspids. Slight mesiolingual torsion of one or both of the superior central incisors is noticeable as in other Indians. In adults with advanced attrition, an edge-to-edge relationship of the incisors is the rule. The following table indicates the number of times the respective teeth were not in normal line of occlusion:

TABLE 1
MALOCCLUSION: 33 SKULLS (11 per cent)

<i>Superior</i>		<i>Inferior</i>	
Third molar.....	1	Third molar.....	7
Second premolar.....	3	Second premolar.....	2
First premolar.....	8	First premolar.....	1
Cuspid.....	12	Cuspid.....	1
Lateral incisor.....	4	Lateral incisor.....	3
Central incisor.....	8	Central incisor.....	1

Suppression of teeth was observed as follows: no. 2677, male, both inferior central incisors; female child, the same; no. 1598, female, all four third molars had not erupted; in four other cases the upper third molars had failed; and in five cases the lower third molars had not appeared.

Supernumerary teeth are frequently described by observers without experience with the various aberrations of both the permanent and deciduous series. Frequently the prolonged retention of deciduous teeth is misleading. Only two cases of supernumeraries were observed: no. 1735, a young adult male with pronounced facial prognathism and having a large left mental foramen, possessed a supernumerary element simulating an upper left fourth molar; and no. 84, male, age about 50, had a supernumerary partially erupted in a horizontal position lingually to left superior bicuspids, and both cuspids were malposed in the buccal embrasures between the bicuspids. Similarly, atypical teeth in these crania occur infrequently, the following only being noted: one instance of a decidedly atypical superior left third molar, an atypical superior right third molar, an upper left second molar with a well developed fifth cusp on the buccal aspect; and a definite bifurcation of the facial root of the superior first premolar, bifurcation of the superior second premolar, and bifurcation of the inferior first premolar, are frequently observed. These bifurcations are of primitive import. The number of small to diminutive teeth are as follows: superior third molar, twenty-eight; inferior lateral incisor, five.

Developmental dystrophies of the dental tissues occur rarely in these crania. There is no evidence of congenital or acquired syphilitic stigmata; nor is there indication of rachitis in the skulls examined. Hypoplastic enamel exists in only two cases: no. 2189 has defective superior third molars; and no. 282 has hypoplastic enamel on the inferior second molars. It is doubtful that attrition obliterated defective formation in other cases. There are no cases of mottled enamel.

To recapitulate, there is no differentiation between the several California groups with regard to racial and developmental features of the dentition. Aboriginal California bears to other Indians racial similarities of the teeth in the following respects: (1) constancy of the prominent marginal ridges of the superior incisors, the shovel-shaped teeth of Hrdlička; (2) occurrence in 4 per cent of persons of a characteristic mesio-lingual torsion of the central incisors; (3) an incidence of about 10 per cent of class 1 (Angle) malocclusion; (4)

preponderance of symmetrical arches which are usually elliptical in form; (5) well developed teeth, true to type, with a few anomalous conditions. The size of the arches and teeth in these crania is average or slightly under, as compared with other Indians. Areas marking the insertions of the muscles of mastication are not greatly roughened, indicating a rather weak masticatory musculature; and this is in consonance with the rather soft diet of these people. Absence of nutritional, glandular, or infectious disturbance during the formative period of the teeth is vouched for by practical absence of hypoplasia in any form. The diet, through variety, doubtless was adequate in its formative constituents. Considerations of this section are not necessarily pertinent to acquired pathologic lesions next to be considered.

ATTRITION

Attrition is the gradual wearing away of the hard parts of the teeth through the physical and physiological agencies of mastication of food. Mastication of narcotics, sometimes mixed with siliceous alkalies, should be included in the foregoing definition; and the result of this habit is invariably of pathologic import. Attrition is usually an accompaniment of senility, in which it is fairly generalized. The degree of attrition may conveniently be classified as follows: first degree is that stage of wear in which the enamel of the cusps is worn without exposure of the underlying dentin; second degree is characterized by obliteration of the cusps with partial exposure of the dentin but still showing enamel at the bottom of the grooves; in third degree the tooth has been considerably shortened, even approaching the neck, completely exposing the dentin; in fourth degree, attrition exposes the pulp. Attrition is common to American Indians, but greatly varies with different tribes. California crania, especially those from the San Francisco bay and central coast, exhibit universal, early, and extensive wear. Attrition, together with its far-reaching *sequelae*, is the outstanding dental lesion in these crania.

The wearing away of the superior teeth takes place on an obtuse plane, the lingual margin being worn deeper than the facial. This plane is exemplified in no. 2486, male, age about 50: the facial surface of the first molar, from the alveolar margin to the occlusal angle, measures 7 mm., while the height of the lingual surface is only 3 mm. In the mandibular teeth concave areas frequently are worn, or in

advanced cases a plane, not so obtuse as on the superior teeth, is formed which slants toward the bucco-cervical margin. In senile individuals with advanced wear, the plane on the superior teeth is shifted to the buccal, and ultimately there is buccal displacement of the apices of the roots following resorption of the alveolar process, with final exfoliation of the worn-down roots. Attrition of the superior teeth is more extensive, occurs earlier, and is causative of far more pathologic *sequelae* than that of the inferior teeth. Not a tooth in the series escaped pulpal exposure through attrition, though it occurs infrequently with the third molars. The superior first molar suffered most, followed in frequency by the superior second molar, superior second premolar, inferior first molar. Children four to five years of age evidence second to third-degree attrition of the deciduous teeth, such as no. 2197. Adolescents show first-degree wear of the first molars.

The following table gives average per cent of attrition in age decades for the entire group. All teeth in any denture are not worn to the same extent, but classification is in accord with general extent of destruction. Individuals aged forty or more at decease are classed together for convenience since fourth-degree attrition does not occur earlier. Hence in this subgroup are good dentures, save for a few teeth whose pulps had been exposed, as well as completely exfoliated dentures of senility.

TABLE 2

ATTRITION

Age group*.....	2			3			4+			
	1	2	3	1	2	3	1	2	3	4
Degree.....	1	2	3	1	2	3	1	2	3	4
Per cent.....	82	18	0	20	75	5	3	17	11	69

* Age groups are approximately 20 to 30; 30 to 40; 40 to senility.

The number of persons over forty in the various geographic groups, who had the pulp in one or more teeth exposed through attrition, is given below. This table supports what a casual physical comparison of the groups indicates: the people who lived on the shores of San Francisco bay were subject to more universal and destructive wear than those of Santa Barbara and the Great Valley. Skulls from the shellmounds show the most destructive attrition. Mussels, salmon, small seeds, and acorns were the principal foods. The technique of

preparation, either through the character of the rock in which the meal was ground, leaching in sand, or disintegration of hot rocks in cooking, rather than the intrinsic nature of the staples, must have been responsible. However, the use of tobacco mixed with burned mussel shells must not be lost sight of, though much of this concoction was directly swallowed rather than chewed.

Gradual attrition is compensated for, in a measure, by protective reaction on the part of the pulp in deposition of secondary dentin; this delays exposure of the vital part. But when destructive centripetal wear surpasses centrifugal deposition of protective secondary dentin, as so frequently occurs with these aborigines, exposure of the

TABLE 3
FOURTH-DEGREE ATTRITION

	<i>Crania</i>	<i>Over 40</i>	<i>With exposed pulps</i>	<i>Per cent</i>
Santa Barbara.....	138	84	48	57
San Francisco bay.....	104	76	58	76
Great Valley.....	50	36	21	58
Nevada*.....	8	6	5	83

* Nevada group is too small to be of comparative value.

formative organ, the pulp, is the result; and pulp exposure is followed by its necrosis and subsequent periapical osteitis, chronic alveolar abscess. Preponderance of fourth-degree attrition as the etiology of osteitis in these crania is set forth under Periapical Osteitis, etc. (p. 415); other deleterious *sequelae* of advanced attrition are discussed under Caries (p. 412) and Periodontoclasia (p. 418).

As the teeth are shortened, the occlusal relationship of the mandible to the maxillae is modified: the distance between the two is shortened, the mandible assumes a slightly forward position which produces an edge-to-edge relation of the incisors, and there are anatomic changes in the temporo-mandibular articulation. Some observers have thought the edge-to-edge arrangement to be a racial characteristic of the American Indian, but it is the result of function and not innate: the occlusion of children and sub-adults shows labial overlapping of the superior incisors and normal position of the first molars. The purview of this paper does not permit extensive data on anatomic changes in the temporo-mandibular articulation accruing from shortening of the teeth through wear, but apparently there is a

tendency with age and shortened teeth to an anteroposterior lengthening of the articular surface of the condyle and decrease in depth of the fossa or resorption of the eminentia articularis:

TABLE 4
TEMPORO-MANDIBULAR ARTICULATION

Skull	Sex	Age	Attrition	Anteroposterior surface condyle	Fossa depth
2821	Male.....	30	1 slight	10 mm.	9 mm.
1601	Male.....	35	2	10 mm.	9 mm.
3406	Female.....	50	3	11 mm.	5 mm.
2488	Male.....	55	3-4	13 mm.	5 mm.

Untoward wearing of the teeth must necessarily be referable to either intrinsic or extrinsic factors: subnormal, loosely constructed dental tissues, or the nature of what is habitually eaten and habits in which the teeth are concerned. A close scrutiny of the teeth in these crania, including little worn enamel of young individuals as well as extensively worn dentin of older persons, fails to disclose hypoplasia or other defective formation, nor is there tendency to fracture. Structurally, the teeth of aboriginal California are inferior to none; therefore the cause is not intrinsic. California culture does not disclose any unusual domestic habit to which the teeth are put, comparable, for instance, to the chewing of the arctic boot by the Eskimo. The cause is doubtless abrasives introduced into the food by the technique of preparation so closely adhered to throughout California; and, possibly, with certain tribes, the chewing of tobacco mixed with mussel shells. The grinding, leaching, and cooking techniques as outlined on pages 403, 404, could not but introduce extraneous sharp abrasives. Neither acorn and small-seed meal nor other articles of aboriginal subsistence are intrinsically abrasive. Thus the California food preparation technique is responsible for universal and extensive attrition which, with its devastating *sequelae*, characterizes the dental pathology of these crania. I have observed attrition of equal or greater degree only in the teeth of a pre-Columbian Algonquin tribe living in Kentucky, of whose diet maize was the staple.

Wear of the teeth produced by friction set up by foreign bodies, such as the pipe, objects used in industrial habits, and in the case of modern people, the tooth brush, is defined as abrasion. Abrasion occurs in only a few of these skulls, and, judging from the teeth worn, is possibly the result of pipe-smoking. But in a few instances, as nos. 1597 and 1605, Santa Catalina, in which the plane of wear is on the lingual surface of inferior incisors, some domestic habit was causative.

CARIES

Dental caries is a molecular decalcification and disintegration of the hard parts of the teeth; it is initiated on the surface and extends pulpward, and is bacterial in character. The occurrence of caries in different races varies widely. An important phase of the pathogenesis of this destructive process is the incidence of localization in the various teeth of the series and their respective surfaces. In the teeth of modern people formative defects in the occlusal surface predispose to caries; in many primitive races the enamel armor is proof, but the susceptible dentin and cementum at the cervix are attacked as the gums recede with advancing age.

TABLE 5
LOCALIZATION OF CARIES IN THE VARIOUS TEETH OF 75 CRANIA IN GROUP OF 300

<i>Superior</i>		<i>Cavities</i>	<i>Inferior</i>		<i>Cavities</i>
Third molar.....	31		Third molar.....	12	
Second molar.....	41		Second molar.....	6	
First molar.....	34		First molar.....	8	
Second premolar.....	15		Second premolar.....	3	
First premolar.....	18		Other teeth immune.....	0	
Cuspid.....	15				
Lateral incisor.....	3				
Central incisor.....	1				
Total.....	158				29
Per cent.....	84				16

Twenty-five per cent of the California skulls evidence dental caries. A comparison with two such well-known tribes as the Sioux and Zuñi, the former a nomadic people who subsisted largely on meat diet and the latter sedentary agriculturalists, shows California with an appreciable incidence of caries against an almost negligible occurrence in the buffalo tribe and a 75 per cent incidence in the maize-eating pueblo tribe. In many dentures only one or two small lesions occur which require close scrutiny to find; while some of the older individuals from Santa Rosa island exhibit extensive caries in from two to a dozen teeth. There is evidence that caries caused the ante-mortem loss of teeth of several old individuals; these are not accounted for in the tables; but exfoliation of teeth was more often resultant from other causes and is considered under Periodontoclasia (pp. 418-422).

The preponderance of cavities in the superior teeth is conspicuous. The immunity of the inferior anterior eight teeth in the series is note-

worthy, but this is in consonance with the relatively lower susceptibility of these teeth in other races. The very few cases of caries of the inferior first molar is in sharp contrast to the incidence of caries in this tooth in modern people, it being the most susceptible in the series. With regard to age at decease of those having carious teeth, there were only two under thirty, one approximately twenty-five, and the other a sub-adult. The greater number were more than forty. A few more males than females were affected.

However, California is not homogeneous with regard to dental caries: a distinct differentiation is evident in table 6. Santa Barbara shows 30 per cent afflicted with caries, and in these cases the lesions, for the greater number, are extensive. Fifty-eight per cent of cavities are located on approximal surfaces, almost all of which began at the cervix beyond the enamel border. Sixty-four per cent of the persons were well over forty at decease, and the dentures have many interproximal diastemata resultant from attrition, periodontoclasia especially in senility, and caries. Food impaction occurred concomitantly and in a causal relationship with caries. No. 271 exhibits food impaction and caries. No. 306 has caries and periodontoclasia progressing simultaneously. Caries and malocclusion are bilaterally symmetrical in cranium no. 319. Caries in this subgroup, however, is not preponderantly of the senile type, as 36 per cent of persons afflicted were between thirty and forty, and 42 per cent of the cavities are on the occlusal surface. On the whole, the Santa Barbara crania exhibit more uniformly extensive carious lesions, as well as slightly more developmental aberrations, than the other subgroups, and remind the writer of the old Zuñi crania, but the latter have far more congenital and acquired lesions. The Santa Barbara people were sedentary; their seasonal migrations, if any, were short. Sea food, some mountain sheep, seeds, acorns, and edible roots were the major items of subsistence. Acorns being less accessible than in other regions, the ratio of plant to animal food was smaller than obtained inland. The marked difference between the dental pathology of Santa Barbara and that of the people of the central and northern coast is not entirely explicable. The proportion of edible roots eaten by the southerners was higher. The difference in attrition indicates a more refined preparation technique in the south. Sandstone rather than basaltic mortars were more frequently used by the inhabitants of the Santa Barbara archipelago and mainland.

The San Francisco Bay people were comparatively free from caries. Of the fourteen cases, three were from thirty to forty at decease, and these had only two small pit lesions each. The eleven were well over fifty, and the lesions had their origin at the cervices of the teeth, beyond the enamel margin, facing interproximal spaces habitually subject to food impaction because of shortening of the teeth through attrition. Friction of their abrasive food inhibited caries, especially up to mid-life; but from fifty to senility, in the eleven cases, attrition and caries are patently intercurrent. When teeth are shortened beyond the approximal contact, food impaction ensues, the gums are crowded beyond the protective enamel, the susceptible cementum, or bare dentin, succumbs to the deleterious

TABLE 6
OCCURRENCE OF DENTAL CARIES IN THE SUBGROUPS AND TOOTH-SURFACE

	LOCALIZATION											
	<i>Crania</i>	<i>Caries</i>	%	-40	+40	<i>Teeth</i>	<i>Cav.</i>	<i>O</i>	<i>Mc</i>	<i>Dc</i>	<i>Lc</i>	<i>Fc</i>
Santa Barbara.....	138	42	30	36	64	110	137	42	28	26	2	2
San Francisco bay....	104	14	12	21	79	30	30	27	34	33	3	3
The Great Valley....	50	18	36	44	56	34	37	46	21	27	3	3
Nevada.....	8	1	12	0	100	2	2	100	.....	.....	..	..

Note: Cavity involving two surfaces is counted twice. O M D L F refer to occlusal, mesial, distal, lingual, facial surfaces; *c* refers to cervix; the figures under these heads are percentages.

influence of carbohydrate débris. Caries, then, occurs in but 14 per cent of the central-coast skulls, and the type of lesion is senile or primitive.

The group of crania from the Great Valley has the highest occurrence with caries, thirty-six. Not only did caries in these people occur earlier in life to a much greater extent than with the coast people, but 46 per cent occurs on occlusal surfaces. The two cases under twenty-five, referred to above, are in this group. Individuals from Sacramento and north have a larger per cent with caries than those from the shores of Kern and Buena Vista lakes. The group is too small and scattered for categorical conclusions; but the following observations are pertinent: (1) the causative agent of caries acted earlier, occurred in a higher per cent, and localized more on occlusal surfaces, and (2) the ratio of plant to animal food of these people was the highest of any. Correlation of these facts is in consonance with the theory of the etiology of dental caries.

Of the eight Nevada skulls, only one, female, age forty, has one occlusal pit lesion in each superior third molar.

PERIAPICAL OSTEITIS AND OTHER PARADENTAL OSSEOUS LESIONS

Pulp exposure from any cause results in its infection and necrosis, with infection via the root foramina of the periapical alveolo-dental periosteum ensuing. The ordinary characteristic tissue change is a low-grade chronic proliferative inflammatory reaction—a productive periodontitis. The alveolo-dental periosteum progressively thickens with a concomitant dissolution of continuity of bone about the apices, thus producing a limited rarefying osteitis. There may or may not be a fistula through the overlying cortical bone. Hyperplasia, and occasionally resorption, of the root cementum is another phase of the tissue reaction. In the skulls of old persons, resorption, together with postmortem loss, exposes the limited cavity in the bone surrounding

TABLE 7
PERIAPICAL OSTEITIS

	Cases	%	Lesions	<i>Etiology, per cent:</i>			
				Attrition	Caries	Fracture	Periclasia
Santa Barbara.....	69	50	177	59	35	4	2
San Francisco bay.....	56	54	267	97	1	1	1
The Great Valley.....	25	50	97	82	18	..	..
Nevada.....	5	63	28	96	....	4	..
Total.....	155	52	569				

Periclasia refers to periodontoclasia (cf. pp. 418-422).

the root apex. These osseous cavities vary in size from about 4 to 30 mm. Some of the larger lesions involve the apices of two or three teeth, frequently the superior first and second molars. As with attrition, so with periapical lesions, these two teeth, in the order named, suffer most, followed by the superior second and first premolars.

Fifty-two per cent of the crania evidence periapical osteitis. With modern people the primary cause of such lesions is almost invariably dental caries; but with the California Indians some 80 per cent of these osseous lesions were resultant from fourth-degree attrition; indeed, 97 per cent were caused by attrition, in the crania from the shellmounds of San Francisco bay. In those from Santa Barbara and the Valley, 35 and 18 per cent respectively were resultant from pulp exposure by dental caries. The high per cent of periapical lesions, together with the primitive cause, characterizes the dental pathology of aboriginal California. In table 7 not all possible lesions are included since many have disappeared with senile resorption of the alveolar process, and a few are not observable without mutilation.

TABLE 8

CYST RADICULAR

No.	Sex	Age	Teeth involved	Miscellaneous
262	F	40	I ¹	
84	M	50	M ¹	Sinus also involved
2330	M	60	I ¹	
2675	M	60	M ¹ Pm ²	Right palate. Osteitis left palate
3500	M	40	I ²	

TABLE 9

MAXILLARY SINUSITIS CHRONIC

No.	Sex	Age	Teeth involved	Fistula	Miscellaneous
269	F	40	M ¹	2 mm.	
286	M	60	Pm ²		
249	M	40	³ M- ² M; M ²	old	Bilateral
317	M	50	² M		Osteitis about C- ¹ Pm
214	F	55	³ M		
84	M	50	M ¹		Cyst associated
3425	M	65	M ¹	5 mm.	
2300	M	60	M ¹ ; ² M	5 mm.	Bilateral
2579	F	60	M ¹ ; ¹ M l. root		Bilateral
3640	F	65	² M	4 mm.	
3667	M	60	¹ M	8 mm.	
3726	M	60	M ¹		
3750	F	55	M ¹	7 mm.	
3685	F	55	M ¹		Extensive osteitis
2727	M	60	M ¹		
3496	M	65	² M- ¹ M	4, 7 mm.	Osteitis about ¹ M ₂ Pm
1713	F	50	¹ M	4 mm.	
2299	F	30	I ¹		Fistula leading into r. <i>naris</i>

Numerals to left of letters indicate from left side; those below and to left indicate inferior left teeth.

SUMMARY OF SINUSITIS

Cases	Per cent	Male	Female	Lesions	Teeth involved
17	6	10	7	20	Pm ² -1, M ¹ -13, M ² -6, M ³ -2

Cyst radicular is a variant of the usual periapical osteitis consequent upon pulp necrosis and periapical infection. There is distinct definition in the extent of this lesion: the wall of the cavity is cortical in contrast to osteoporosis of the wall of an ordinary alveolar abscess; and the osseous covering on the facial or palatal aspect may be attenuated to a parchment-like membrane. In the fresh state, this lesion is characterized by a lining of epithelium and the sack is filled with liquid or viscid material. The genesis of radicular cyst is proliferation of the epithelial rests of Malassez in the alveolo-dental periosteum stimulated by periapical infection. This is the only type of dental cyst occurring in these crania.

TABLE 10

GROSS PARADENTAL OSSEOUS LESIONS

No.	Sex	Age	Teeth	Cause	Lesion
1598	F	50	Pm ₁	T. fracture	Osteomyelitis
316	M	40	¹ M	T. fracture	Osteomyelitis
313	M	55	₂ M- ₂ M		Osteoperiosteitis, lingual surface
365	M	60	₃ M below	Trauma	Osteitis—traumatic, on margin mandible
2529	M	55	I ₂ -C		Osteitis
1666	M	50	M ₂		Osteitis
2300	M	60	₂ I-I ₂		Osteitis
3470	M	50	Pm ² -M ¹		Osteitis
3500	M	40	₁ C		Osteoperiosteitis, old fistulae
3478	F	60	₁ Pm-I ₁	Attrition	Osteitis

Maxillary sinusitis chronic resultant from extension by continuity of periapical osseous lesions is plainly observable in the cases listed below, and may be present in a few other skulls in which the involved teeth are *in situ*. Fistulae leading from the sinus to alveoli, or more exposed surfaces, measure from 4 to 8 mm. in diameter; their edges and walls are well rounded, smooth, and sclerosed, pathognomonic of chronicity. There are three cases of bilateral sinusitis. The first molar was involved in more than half the lesions. More than half the cases are from the central coast; and evidently there is a correlation with the high per cent of osteitis present. Most of the individuals were old.

Osteomyelitis of the maxillary bones consequent upon the introduction of infection through the teeth usually produces a rapid, diffuse inflammation and destruction of all parts of the bone: the walls of the lesions are porous and the margins ragged. It is indicative of high virulency of the infective agent. This type of bone

destruction frequently follows tooth fracture. In some other bone infections the periosteum and surface of the cortex are mainly involved, *osteoperiosteitis*.

Adamantinoma is a tumor produced by aberrant proliferation of enamel epithelium; one type is calcified. No. 351, male, age 60, has such a growth on the right facial aspect near the premolars. Absence of the cortical bone exposes the calcified tissue débris.

PERIODONTOCLASIA

Periodontoclasia is a chronic destructive degeneration of the investing tissues of teeth which eventuates in exfoliation. This study is concerned with dry crania, therefore observations on changes in the alveolar bone only can be made. *Alveoloclasia* is the breaking down of the alveolus; in this study this latter term will be largely used. From childhood to senility there is a gradual recession of the crest of the alveolus from the enamel margin; this necessarily is a physiological condition, not a pathological process. To differentiate between the normal position of the alveolar crest and appreciable deviations therefrom, a norm for different decades of life must be sought. The distance from the enamel border to the alveolar crest at the mesio-facial angle of superior and inferior first molars in skulls in good condition and free from dental lesions was measured; the following are representative:

TABLE 11
ALVEOLAR ATROPHY

<i>Example</i>	<i>Age</i>	<i>Superior first molar</i>	<i>Inferior first molar</i>
3494	child 7	crest even with enamel	crest even with enamel
340	child 14	0.5 mm.	0.5 mm.
2356	20	2 mm.	1 mm.
2617	30	2.5 mm.	1.5 mm.
2821	40	3 mm.	2 mm.
338	50	4 mm.	3 mm.
350	60	5 mm.	5 mm.
365	senile	measurements impracticable	

Alveoloclasia, however, is not uniformly a mere even atrophy of the free margin of the alveolus but may involve enlargement of its lumen, dissolution of the thin cortical lining (*lamina dura*), osteoporosis of the walls, mobility of the tooth, or resorption of the external cortical plate, and finally exfoliation. Alveoloclasia, then, may be

differentiated into two types: (a) a characteristic resorption of the crest, including the interproximate septum; and (b) an intra-alveolar resorption. In many cases of alveoloclasia of the molars, especially the inferior second and third, there is a scroll-like eversion of the facial margin with irregular nodular deposits of bone formed on the old cortex; these accretions are osteophytes. In not a few of the skulls with evidence of alveoloclasia, attrition, caries, bone resorption, and postmortem loss have destroyed hard tissues beyond measurement, so that the ensemble of alveolar resorption must be considered, particularly in cases of advanced age. In fact, alveoloclasia manifest in these crania is mostly a concomitant of age; and in persons younger than sixty, it is, in effect, a precocious senile alveolar atrophy.

By the deposition of bone beyond the apices, roots have gradually been extruded: shortening by attrition has thus been compensated in part. But with the continuous eruption of shortened teeth, abetted by mutilation through partial or complete loss of teeth from the arch, incongruous occlusal planes are gradually established. Inharmony of occlusal relationship has resulted in extreme leverage on the remaining dental units with consequent resorption of the alveolar walls, on the side of apical pressure, with ultimate exfoliation, which is more often through the facial wall. The vicissitudes of functioning have altered the position and angle of many units; there has been continued equilibrium of deposition and resorption of the supporting alveolar bone to accommodate the migrating dental units in their function. Much adaptive economy is shown in the dentitions of the older persons. But ultimately resorption has superseded deposition. It is remarkable that when the wear is even, and without destruction of approximate contacts, the alveolar bone is dense to sixty years or later. No. 2678 is such a case. Beyond this age general osteoporosis of the cranium gradually takes place; this is one phase of the physiological involution of senescence. The resorption of the alveolar bone is an early manifestation of senile osteoporosis; and many teeth are thus exfoliated. The dentition has manifestly served its function: the teeth and their supporting structures are truly transitory; also the maxillae and mandible undergo marked diminution. These skeletal changes are to be regarded as physiological rather than pathological.

Etiologically, the following observable facts are to be considered: (a) Particularly in crania from the shellmounds, attrition is the first and basic destruction in a vicious series of pathological processes: shortening of the teeth, pulp exposure and necrosis, periapical osteitis,

continued shortening with loss of approximal contact thus producing pathological diastemata, habitual food impaction; resorption of interseptal bone. The shortened teeth concomitantly are subjected to unusual occlusal stresses, particularly leverage, and the mechanics of the mutilated dentures indicates that untoward stresses have stimulated continued resorption of alveolar bone overlying the area of roots bearing an undue burden, until the end-result, exfoliation, has eventuated. Where attrition is on a horizontal plane facio-lingually, and not to the extent of the production of pathological diastemata, and in the absence of the loss of teeth, stresses are evenly distributed, and critical examination shows the walls and crest of the alveoli well preserved to sixty years or later. (b) Resorption of the distal support of the superior third molars allows a backward tipping of these teeth in function, production of pathological diastemata, impaction of food, inflammation and resorption of the interdental septum. (c) Mutilation of arches by the loss of some units, such as the first molars, from attrition or caries, is followed by shifting of neighboring teeth in the arch thus producing diastemata, which in turn affords food impaction with consequent resorption of septum, and, withal, this shifting of the units produces abnormal occlusion with untoward stresses, and augmented resorption is inevitable. This series of changes is exemplified in the loss of the inferior right first molar of no. 2681. (d) In older individuals there is patently a correlation between periapical osteitis and alveoloclasia: the former is conducive to the latter, probably because of the presence of active cellular elements concerned with bone resorption. In many skulls alveolar atrophy has fused with periapical lesions. (e) In many skulls with pathological diastemata, loss of contact between teeth, irrespective of cause, there is not only resorption of the interdental septum, but, because of food impaction, caries is initiated at the susceptible cervix. Interstitial food impaction, resulting in caries and periodontoclasia, is exemplified in nos. 271 and 306; in the latter these two universal dental pathological processes have progressed together. The concept that caries and periodontoclasia are incompatible and do not occur concomitantly is fallacious. (f) Alveoloclasia in these skulls is rare about anterior teeth; this is in contrast with the condition of modern people. (g) In short, local trauma and malfunction are the proximate deleterious conditions which initiate periodontoclasia; and alveoloclasia is augmented and accelerated by systemic senile osteomalacia. (h) Extraneous deposits, though generally present, evidently do not hold a

major causal relationship to alveoloclasis: dentitions with sizable accretions are relatively free from resorption of the alveolar process; dentitions free from deposits are affected; and the usual site of alveolar degeneration, about the second and third molars superior and inferior, is not the locus for heavy salivary deposits. Exceptions to the above, wherein large accretions parallel horizontal resorption of the crest, are nos. 3645 and 3406 (latter illustrated as pl. 65*b*). Doubtless extraneous deposits cause mild marginal irritation. There is no evidence of dental hygiene in any form being practiced; neither has there been dental mutilation.

Degeneration of the alveolus occurred later in life with the San Francisco Bay people than with the others, and generally as an aftermath of attrition and its *sequelae*. The following table indicates the occurrence of distinct alveolar degeneration in crania from the different localities and with respect to age of persons at decease.

TABLE 12

PERIODONTOCLASIA

	<i>Per cent</i>	<i>No.</i>	<i>30+</i>	<i>40+</i>	<i>50+</i>	<i>60-senility</i>
Santa Barbara.....	46	63	6	11	16	30
San Francisco bay.....	48	50	..	2	17	31
The Great Valley.....	48	28	3	7	10	8
Totals.....	47	141	9	21	43	69

The table below shows the respective teeth affected by alveoloclasis in the 141 skulls. As several mandibles are missing, the per cent of inferior teeth involved is disproportionately low. This table bears a strong similarity to table 14 giving teeth lost antemortem.

TABLE 13

TEETH INVOLVED IN ALVEOLOCLASIA

<i>Teeth</i>	<i>141 Skulls: Per cent</i>	
	<i>Superior</i>	<i>Inferior</i>
Third molar.....	67	36
Second molar.....	66	34
First molar.....	65	32
Second premolar.....	33	13
First premolar.....	24	11
Cuspid.....	13	7
Lateral incisor.....	21	8
Central incisor.....	24	9

These aborigines lost very few teeth before middle life. Only ten individuals younger than forty at decease show loss of any teeth. Most cases with teeth missing were well over fifty years. Considerably more superior than inferior teeth were lost, although the per cent of inferior teeth shown in the table is disproportionately low due to the absence of several mandibles. There is no distinctive difference between the groups, save that Santa Barbara did not lose so many superior first molars and second premolars through attrition as did

TABLE 14
TEETH LOST ANTE MORTEM

	<i>S. B.</i>	<i>S. F.</i>	<i>V.</i>	<i>S. B.</i>	<i>S. F.</i>	<i>V.</i>
Individuals.....	67	55	28	....	....	....
Edentulous cases.....	5	2	0	....	....	....
<i>Absolute per cent</i>		<i>Superior</i>			<i>Inferior</i>	
Third molar.....	41	36	32	20	15	16
Second molar.....	36	34	21	7	7	16
First molar.....	33	48	44	9	5	25
Second premolar.....	15	22	16	9	2	9
First premolar.....	12	11	3	8	1	8
Cuspid.....	3	3	0	2	0	1
Lateral incisor.....	5	17	7	8	1	7
Central incisor.....	10	24	3	13	2	16

the others. The major causes of antemortem loss are: (a) periapical osteitis consequent upon pulp exposure through attrition, particularly of the superior first molars; (b) periodontoclasia of the second and third molars; and (c) generally, senile osteomalacia.

SUMMARY

The indigenous people of California were fairly sedentary, living in permanent village sites determined largely by food supply; they made only short seasonal migrations in quest of food. Their life was closely adapted to their habitat, and dependence on the local edible flora and fauna was absolute. Plants furnished the larger part of the dietary; the acorn was the staple, supplemented by small seeds. Fish and mollusks were consumed in large quantities where available; rodents, birds, and deer were important additions. Tobacco was in common use; some tribes mixed it with burnt mussel shells and ate it. The California food-preparation technique, grinding on basaltic stones, leaching in sand, cooking with hot stones, introduced much abrasive material which affected the teeth deleteriously.

The California palate is rather short, symmetrical, and somewhat elliptical in form. The masticatory musculature is rather weak. The teeth are average or small in size; they are structurally without defects and present few aberrant forms. Morphologic features of note, fairly common to American Indians, are: prominent marginal ridges on the superior incisors, streaming of enamel into the bifurcation of molar roots with frequent detached enamel pearls, rather broad superior lateral incisors, and a small incidence of a characteristic torsion of superior central incisors and first premolars.

Attrition, together with its pernicious *sequelae*, is the conspicuous dental lesion in these crania. Not a tooth in the series escaped pulpal exposure through attrition. Seventy per cent of persons over forty years of age had the pulp of one or more teeth exposed.

Dental caries occurred in 25 per cent of the skulls. Crania from Santa Barbara and the Great Valley showed some 30 per cent in contrast with the low incidence of 12 per cent in specimens from the shell-mounds. Friction of the abrasive food of the latter inhibited caries. More than 50 per cent of carious lesions are located on proximo-cervical areas: senile or primitive caries.

Dissolution of continuity of bone surrounding the apices of teeth occurs in 52 per cent of crania. These osseous lesions are resultant from pulp exposure and necrosis; and the primary cause of infection was attrition in 97 per cent of cases from the Bay region; while attrition was the dominant cause in the other groups, 35 and 18 per cent in crania from Santa Barbara and the Valley, respectively, were consequent upon caries. Other gross paradental bone lesions resultant from dental infection are: radicular cyst, chronic maxillary sinusitis with fistulae leading into alveoli, and osteitis in various forms.

Periodontoclasia is manifest in about 50 per cent of these crania, most of which were well beyond middle life at decease. Teeth most often affected are in order: third, second, first molars, second premolar. Exfoliation of teeth as a phase of the involution of senescence is widely manifest.

SPECIMEN NUMBERS

The data contained in this paper are based on the following crania in the University of California Museum of Anthropology, the key number 12- being omitted:

Santa Barbara region: 105, 118, 212, 213, 214, 215, 216, 217, 218, 219, 220, 221, 222, 223, 224 225, 227, 228, 229, 230, 231, 232, 233, 234, 235, 236, 238, 240, 241, 242, 244, 245, 246, 247, 248, 249, 250, 251, 252, 253, 255, 256, 258, 259, 261, 262, 263, 264, 265, 266, 267, 268, 269, 270, 271, 272, 273, 274, 275, 276, 277, 278, 279, 280, 281, 282, 283, 284, 285, 286, 287, 288, 289, 291, 292, 293, 294, 295, 296, 297, 298, 299, 300, 301, 302, 304, 305, 306, 307, 308, 309, 310, 312, 313, 314, 315, 316, 317, 318, 319, 320, 322, 323, 324, 325, 331, 340, 341, 345, 363, 372, 433, 1695, 1697, 1711, 3467, 2198, 1597, 1598, 1599, 1601, 1602, 1605, 1606, 1607, 2184A, 2188, 2180, 2181, 2183, 2187, 2176, 2177, 2174, 2189, 2196, 2205, 2206.

San Francisco Bay region: 66, 67, 68, 69, 70, 71, 72, 73, 76, 77, 79, 80, 82, 84, 85, 556, 1666, 1714, 2125, 2133, 2299, 2300, 2302, 2330, 2353, 2354, 2356, 2357, 2405, 2460, 2475, 2486, 2487, 2492, 2494, 2496, 2499, 2505, 2511, 2512, 2529, 2546, 2548, 2549, 2553, 2571, 2579, 2582, 2674, 2675, 2677, 2784, 2785, 2786, 2800, 2802, 2821, 3402, 3403, 3425, 3437, 3455, 3480, 3608, 3612, 3613, 3613A, 3631, 3633, 3640, 3641, 3644, 3652, 3663, 3667, 3670, 3677, 3679, 3685, 3690, 3697, 3701, 3702, 3706, 3707, 3713, 3715, 3718, 3726, 3728, 3729, 3740, 3645, 3748, 3750, 3752, 3765, 3853, 2488, 2476, 2503, 3669.

Great Valley: 1734, 1735, 1736, 1737, 2203, 2204, 2424, 2722, 2723, 2724, 2725, 2726, 2727, 2727B, 2728, 2729, 2730, 2731, 2732, 2744, 3406, 3471, 3473, 3473B, 3495, 3496, 3498, 3500, 3501, 3502, 3503, 3504, 3505, 3506, 3507, 3510, 3851; 78, 446, 1712, 1713, 2427, 2428, 2678, 2681, 2704, 3460, 3461, 3469, 3470.

Nevada: 2614, 2617, 2618, 3478, 3479, 3492, 3493, 3494.

BIBLIOGRAPHY

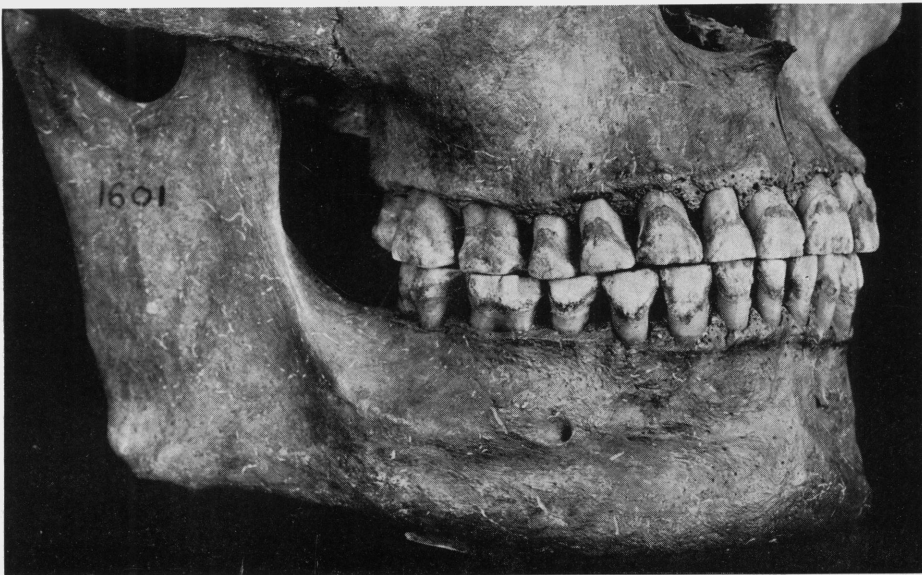
- E. W. GIFFORD. Californian Anthropometry, Univ. Calif. Publ. Am. Arch. Ethn., 22:217-390, 1926.
- A. HRDLIČKA. Contribution to the Physical Anthropology of California, Univ. Calif. Publ. Am. Arch. Ethn., 4:49-64, 1906.
- A. HRDLIČKA. Shovel-Shaped Teeth, Am. Jour. Phys. Anthrop., 3:429-465, 1920.
- A. L. KROEBER. Handbook of the Indians of California, Bur. Am. Ethn., Bull. 78, 1925.
- R. W. LEIGH. Dental Pathology of Indian Tribes of Varied Environmental and Food Conditions, Am. Jour. Phys. Anthrop., 8:179-199, 1925.
- SIR M. A. RUFFER. Studies in the Palaeopathology of Egypt, Chicago, 1921.

EXPLANATION OF PLATES

PLATE 60

Skull 1601, Santa Catalina island. Male, age about 30. Typical specimen with normal occlusion and without pathologic lesions. Function has produced second-degree attrition. The lower right third molar is suppressed and the upper right third molar is diminutive. Slight salivary accretions are present. The distance from the crest of the alveolus to enamel margin on the mesiofacial angle of the upper first molar is 4 mm., on the lower first molar is 2 mm.

Skull 2744, Kern county. Male, age about 30. Massive mandible. Measurements: width between sigmoid notches 105 mm., width between facial aspects of first molars 62 mm., height of ramus from angle to crest of condyle 90 mm., height of symphysis from lower border to crest of alveolar process 37 mm., length from mental process to posterior border of ramus 90 mm. There is suppression of the third molars; and second-degree attrition of the teeth. The cervical border of the enamel of all the teeth is uniformly discolored with a light brown stain, probably produced by tobacco or other vegetal agent.



1601, SANTA CATALINA ISLAND

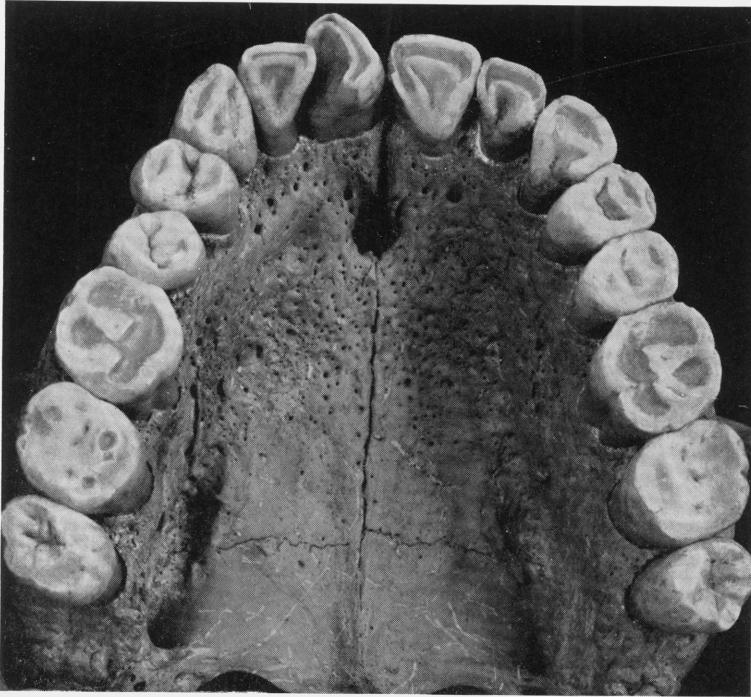


2744, KERN COUNTY

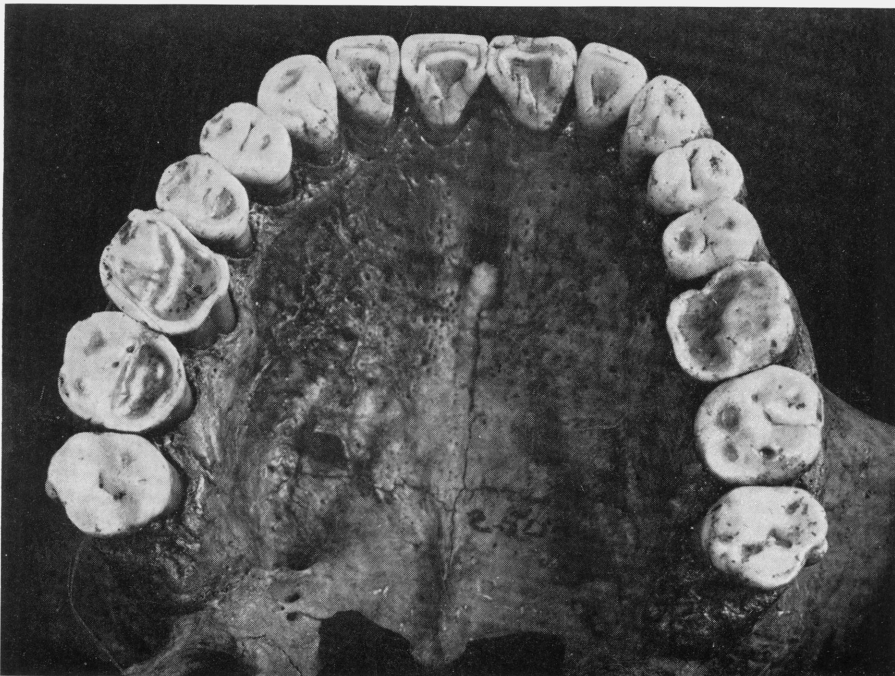
PLATE 61

Skull 1606, Santa Catalina island. Male, age about 25. Malocclusion (class 1, Angle). Malposed right central incisor and right second premolar; the latter is rotated nearly 180°. Large elliptical arches, and characteristic prominent marginal ridges on incisors. Second-degree attrition. The distance from the alveolar border to the enamel margin on upper first molar is 4 mm., on lower first molar 2 mm.

Skull 2503, Mountain View. Male, age about 35. Large parabolical arch with full complement of teeth. Prominent marginal ridges on upper incisors, as exemplified in this specimen, are a physical characteristic of the American Indian. There is second-degree attrition, heavy salivary accretions, and a small carious pit in occlusal surface of left second molar. The distance from the alveolar border to enamel margin on upper first molar is 4 mm., on lower molar 2 mm.



1606, SANTA CATALINA ISLAND

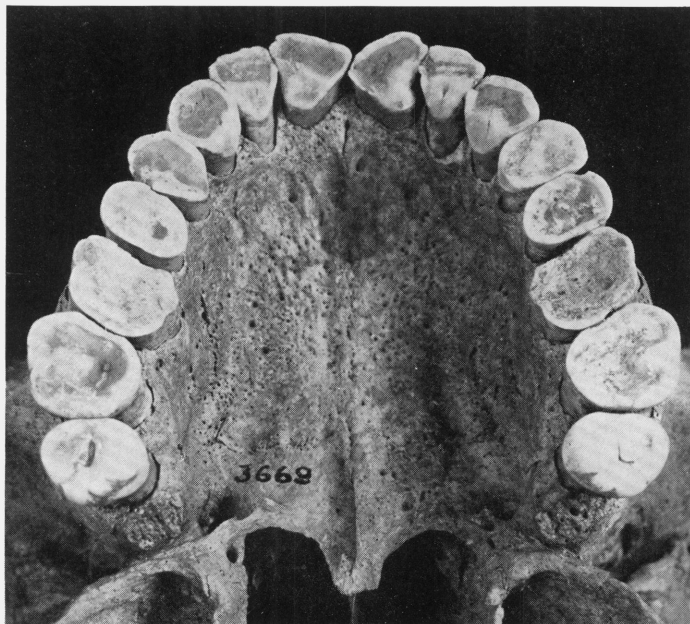


2503, MOUNTAIN VIEW

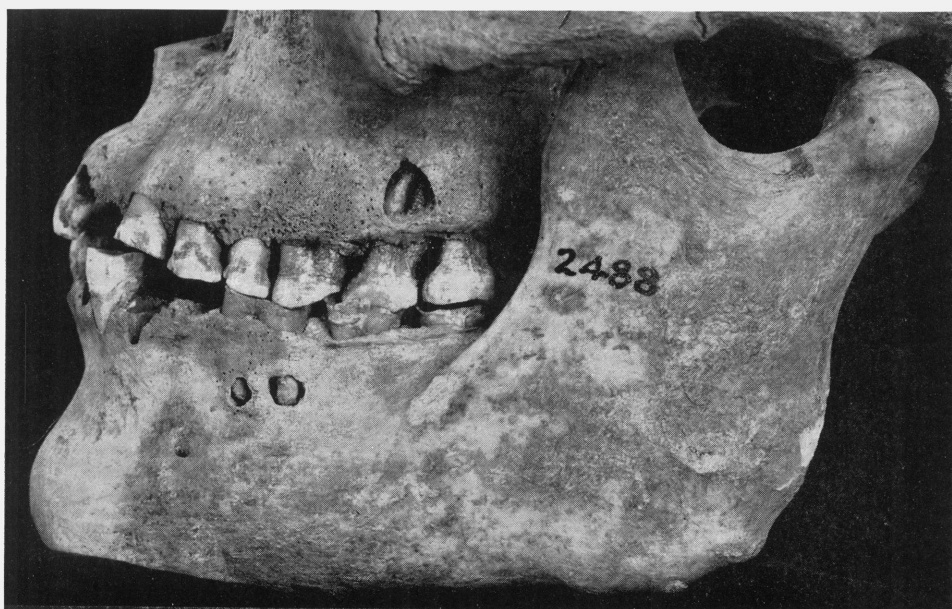
PLATE 62

Skull 3669, Emeryville mound. Male, age about 50. Torso-occlusion of central incisors: there is a mesiolingual rotation, which condition is present in an appreciable per cent of American aborigines. Function has resulted in third-degree attrition of the first molars and second-degree of the other teeth. There are no pathologic lesions.

Skull 2488, Mountain View. Male, age about 55. Periapical osteitis. Facial aspect showing periapical osteitis resultant from fourth-degree attrition of upper left first and second molars and lower first molar. Similar lesions are present about the upper right first and second molars, which are not shown in this view. The facial portions of the lower molars have been worn to the cervixes. Left upper incisors and lower premolars have been lost postmortem. (Compare with occlusal aspects of same skull shown on pl. 63.)



3669, EMERYVILLE MOUND

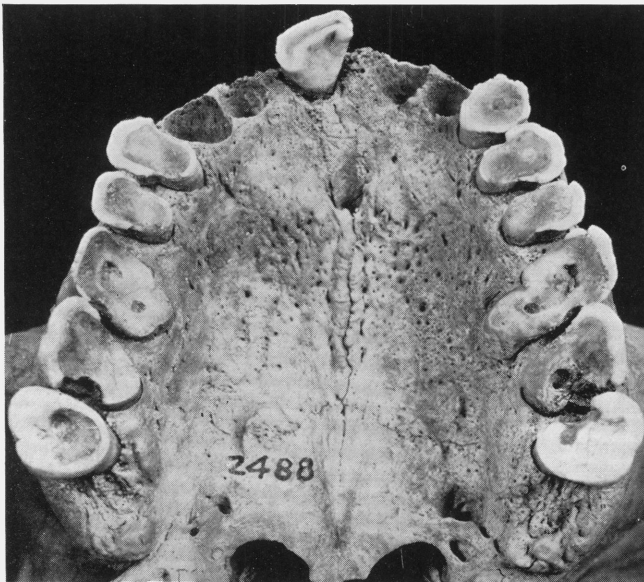


2488, MOUNTAIN VIEW

PLATE 63

Skull 2488, Mountain View. Oclusal aspect of upper denture of skull shown in plate 62. Third and fourth-degree attrition. The pulps of the first and second molars on both sides have been exposed through wear, thus providing a tria for periapical infection with resultant osteitis as shown in the palate about the lingual root of the left first molar, which has been entirely denuded of bone, as well as the lesions shown in the facial aspect. The plane of wear of the upper teeth is always obliquely upward from the ocluso-facial angle to the linguo-cervical region. The extreme wear has destroyed contact between the teeth, which condition has permitted interstitial food impaction with concomitant caries. Large carious lesions exist on the interproximal surfaces of the second and third molars bilaterally, also on oclusal surface of right third molar. Four anterior teeth have been lost post-mortem.

Skull 2488, Mountain View. Oclusal aspect of lower denture shown in plate 62. Third and fourth-degree attrition. The pulp of the left first molar has been exposed with consequent periapical osteitis as shown in the facial aspect. The plane of wear on the lower teeth always runs obliquely downward from the linguo-occlusal angle to the facio-cervical region, the complement of the plane worn on the upper teeth. Secondary dentin has been formed in the pulp chambers of the teeth but without avail against the centripetal destruction in the teeth noted. A carious lesion is in the mesio-cervix of the right first molar. Premolars and incisors not present have been lost postmortem.



2488, MOUNTAIN VIEW

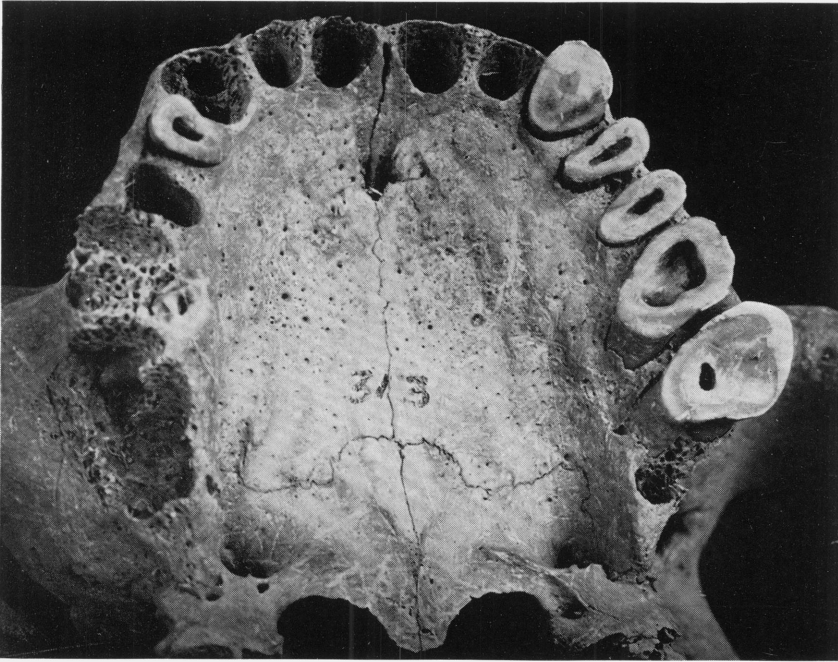


2488, MOUNTAIN VIEW

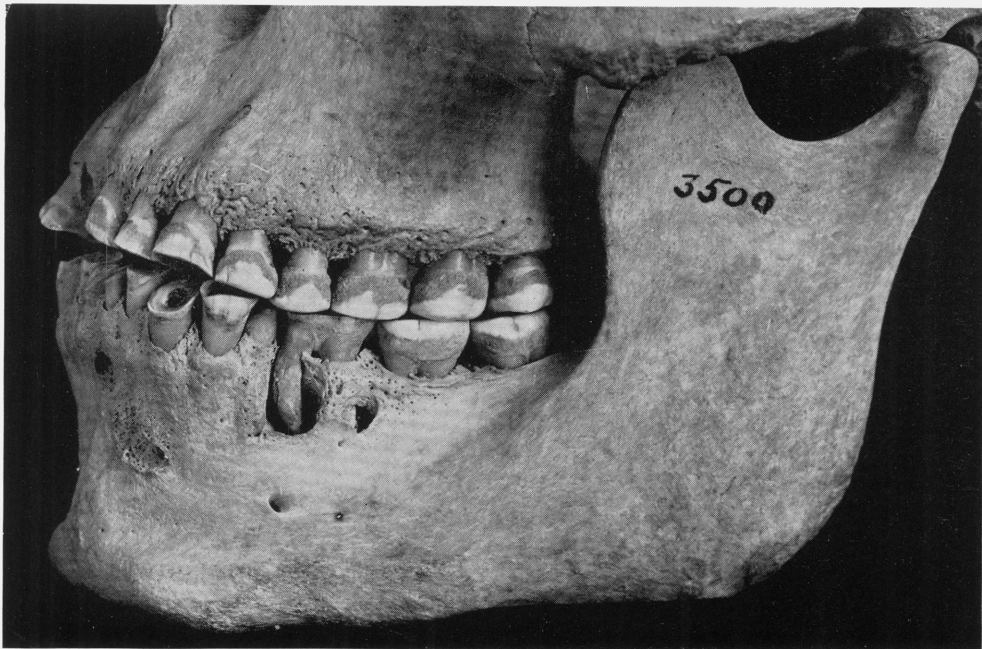
PLATE 64

Skull 313, Santa Rosa island. Male, age about 55. Extensive fourth-degree attrition. The pulp chambers have been fully exposed. Eight periapical osseous lesions have resulted from these exposures with eventual exfoliation of the right molars.

Skull 3500, Kern county. Large male, age about 35. Abrasion of the teeth, probably through some occupational habit, has exposed the pulps of the lower right central incisor, left cuspid, and left first molar. Old fistulae with condensed smooth margins lead into extensive osseous cavities. Chronic osteoperiosteitis is evident over the cuspid root. Note the extensive bone destruction about the molar. The lower left second premolar is malposed lingually.



313, SANTA ROSA ISLAND

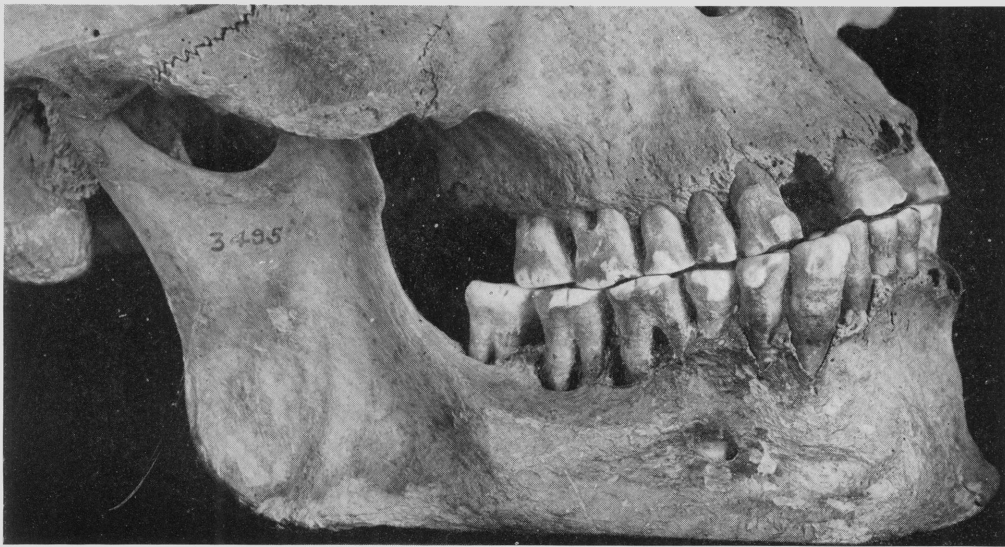


3500, KERN COUNTY

PLATE 65

Skull 3495, Kern county. Male, age about 50. Alveoloclasia (clinical periodontoclasia or pyorrhea alveolaris) about the molars. Intra-alveolar resorption of the bone is evidently of long continued chronicity: the margins are smooth and condensed. The distance from the alveolar border to the enamel margin on the upper first molar is 6 mm., on lower first molar is 7 mm. Note the resorption of bone is far beyond the bifurcation of the roots. Heavy salivary accretions are present.

Skull 3406, Kern county. Male, age about 60. The mandible is nearly edentulous; the anterior portion was being actively resorbed at time of disease: note the porosity. The pulps of six of the lower anterior teeth have been exposed through fourth-degree attrition with resultant periapical lesions. There are extremely heavy salivary accretions on the upper teeth. The upper left molars have been exfoliated, and the disto-buccal root of the right first molar has been lost through caries. Interstitial periodontoclasia is uniformly present. Thus a complex of the common dental disease processes is causing loss of the teeth and resorption of the alveolar process, which, together with beginning cranial porosity, is indicative of senility.



3495, KERN COUNTY

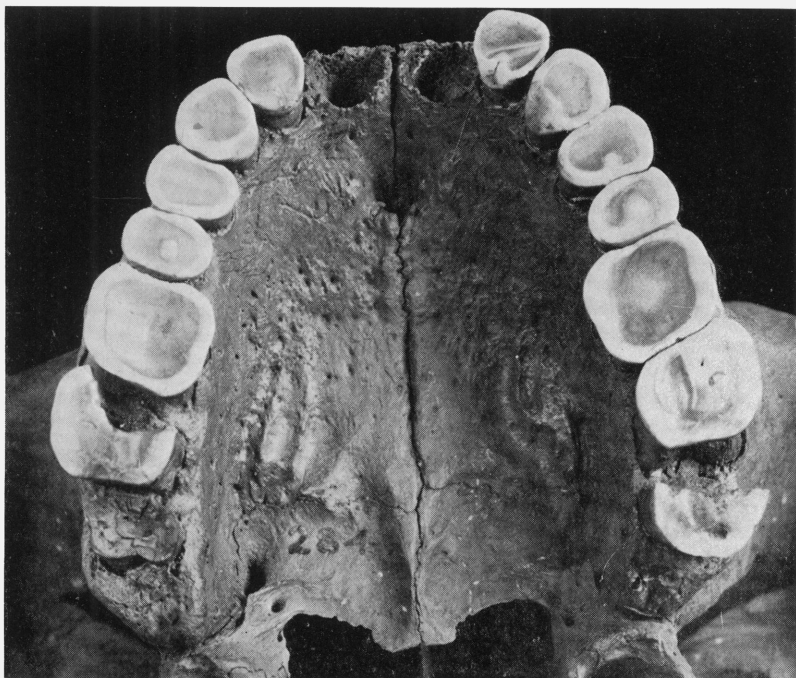


3406, KERN COUNTY

PLATE 66

Skull 284, Santa Rosa island. Female, age 40. Dental caries. Caries has destroyed the crown of the right third molar, the greater part of the right second and left third molars, and has also deeply penetrated from the distal cervix the right first and left second molars. Periapical osteitis, not shown in this view, is resultant from the carious lesion in each of the above first three teeth. Interstitial food impaction between the carious teeth has evidently caused resorption of the alveolar septa. This specimen exhibits the usual localization of caries in this group: the posterior teeth are the most liable to caries; and the tooth cervix is the most susceptible area. This denture has normal occlusion, and second degree attrition which suggests vigorous functioning. The mandible of this case shows intra-alveolar resorption with accompanying buccal eversion of the margin about the molars.

Skull 270, Santa Rosa island. Male, age 45. Adamantinoma. Alveoloclasia. In the alveolar process facially to the right cuspid and first premolar is a hard-tissue neoplasm approximately 1 cm. in diameter. The mass is composed of several amorphous enamel elements combined with other hard tissue; its genesis has apparently been aberrant enamel germs and, therefore, the growth is an adamantinoma. Ravages of periodontoclasia are much in evidence: seven teeth in the mandible have been exfoliated; the typical lesion is evident about the roots of the lower first molar; the pathological process has produced a parietal abscess in the alveolus of the lower right second premolar, and also in the alveolus of the lower left second molar, the latter not shown in this view. The periapical osseous lesion connected with the upper right first molar is resultant from pulpal exposure through wear, fourth-degree attrition.



284, SANTA ROSA ISLAND

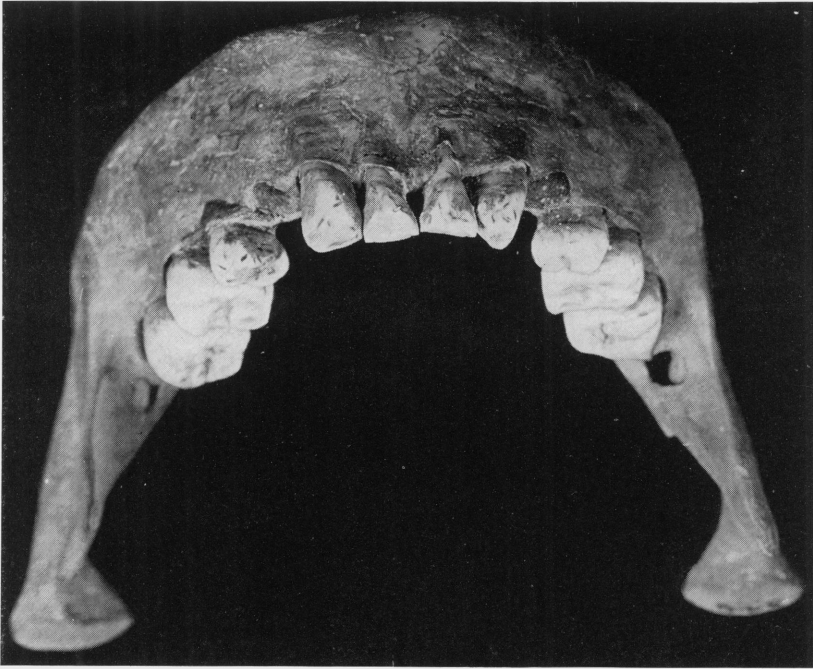


270, SANTA ROSA ISLAND

PLATE 67

Skull 340, Santa Rosa island. Male child, age about 14. Suppression of lower central incisors; this condition is of infrequent occurrence. The right cuspid is slightly malposed, there being a facial rotation of the mesial angle. There is an appreciable wear of the enamel cusps, first-degree attrition, which is typical of the teeth of children in this group. Extraneous deposits are evident. The distance from the alveolar crest to the enamel margin of the first molar is .5 mm.; compare this with corresponding measurements in adults.

Skull 2476, Mountain View. Female, age 35. Malocclusion. This is an unusual case of impacted, partially erupted upper right cuspid and first premolar: the cuspid is lying at an obtuse angle in the palate with crown pointing upward and facially at wing of nares; the premolar is in a horizontal plane with its root in contact with that of the cuspid; the cuspid is probably responsible for the malposition of the premolar. Physiological urge to erupt these teeth has involved extensive osseous disturbance which has resulted in resorption of the alveolar support of the lateral incisor with its consequent loss. Note the tenuous semi-circle of bone about the premolar. The left cuspid, not shown in this view, is rotated 90° on its axis; the lower left central, lost postmortem, is rotated to a lesser degree.



340, SANTA ROSA ISLAND



2476, MOUNTAIN VIEW