Eskimos and Aleuts: Their Origins and Evolution

Physiological and cultural adaptation facilitate the evolutionary success of the Eskimo-Aleut stock.

William S. Laughlin

Eskimos have been known to the European world since A.D. 1000, when Leif Erikson found them on the coast of Labrador. The Greenlandic Eskimos and their relatives the Aleuts and Eskimos to the west and north were by no means newcomers to North America and Greenland. At the time of their discovery by Leif they had been living in the New World for over 4000 years.

In the more than five millennia that have passed since these Mongoloid peoples migrated from Siberia to Alaska, they have worked out a remarkable system of adaptation to a series of diverse environments, ranging from the harsh climate and poorly lighted terrain of the polar regions to the more moderate marine environment of the Aleutian Islands. Their adaptations, physiological and cultural, have enabled them to occupy the entire coast of northern North America, from Alaska to the northeastern coast of Canada, and the entire coast of Greenland. Because of their antiquity, the evolutionary changes in successive groups, and the variations throughout their distribution over a long coastal area, the Eskimos and Aleuts provide a unique opportunity for studying microevolution, population history from the standpoint of genetics, and biological and cultural adaptation. Such studies have been facilitated by the excavation of stratified village sites rich in durable artifacts and in faunal remains and human skeletons, many of them showing direct continuity with living groups. Moreover, studies of the blood groups of living individuals show a basic similarity between Aleuts and Greenlandic Eskimos, as distinguished from American Indians, who are much less Mongoloid. In addition, the linguistic diversity within a single stock provides an invaluable means of tracing the impressive florescence of these energetic and practical peoples.

The author is professor of anthropology at the University of Wisconsin, Madison.

Linguistic Characterization

The three distinctive languages spoken by members of this stock differentiate them from American Indians and indicate a connection with Siberian Mongoloids that is confirmed by the serological and morphological evidence. The two Eskimo languages and the Aleut language differ to the extent that an individual who speaks Eskimo cannot understand Aleut, but phonologically and grammatically they are quite similar. Rasmus Rask first noted the basic similarity between Greenlandic Eskimo and Aleut in 1819. Inyupik Eskimo is spoken in northern Alaska and Canada as well as in Greenland. The second Eskimo language, Yupik, is spoken in western Alaska south of Unalakleet on Norton Sound—the area where most of the Siberian Eskimos live—and by the Eskimos of St. Lawrence Island in the Bering Sea. There are at least four dialects of Yupik, and communication between individuals who speak different dialects is difficult. Edward Sapir noted this diversity and formulated a useful working principle (*1*): "The greater the degree of linguistic differentiation within a stock, the greater . . . the period of time that must be assumed for the development of such differentiation." He concluded that the divergence between Aleut and Eskimo and the diversity of dialects within them pointed to southern Alaska as the earliest center of dispersion. Later, a method of dating on the basis of linguistic characteristics (called glottochronology or lexicostatistic dating) was applied by Marsh and Swadesh (*2*), who estimated that the Aleut and Eskimo languages had separated some 3000 years ago. They based this estimate on an assumed retention rate and on the number of words Aleut and the Eskimo languages now have in common. This date has more recently been revised to about 4500 years ago, the subsequent separation of the two major divisions of Eskimo being placed close to 1400 years ago (*3*). The possibility that there was a connection with the Siberian languages Chukchi-Koryak and Kamchadal some 5000 years ago has recently been suggested (*4*). Other linguists, though not necessarily proponents of the glottochronological method, generally agree that the differentiation took place in southern Alaska and that the speakers of Yupik moved from south to north (*5*). These estimates fit well with findings which indicate that, at the time of the exploration of Bering and Steller in 1741, southwestern Alaska was the area of highest population density (*6*). At that time some 7000 Koniag Eskimos lived on Kodiak Island, and 16,000 Aleuts inhabited the Aleutian Islands and the western part of the Alaska Peninsula. A few hundred Eskimos lived in the interior of the Alaska Peninsula, in northern Alaska, and in the Barren Grounds of Canada (*7*).

Anangula

The archeological evidence also points to southern Alaska as the homeland of the Eskimo-Aleut stock. The oldest known site in the Eskimo-Aleut world, according to dates obtained by the radiocarbon technique, is the lamellar-flake site on Anangula Island, 5 miles off the shore of Umnak Island, opposite the present village of Nikolski on the Bering Sea side. Three dates have been obtained from a cultural level underlying two layers of ash and humus; these are 8425 ± 275 years ago (Isotopes Inc. specimen I-715), 7990 ± 230 years ago (Isotopes Inc. specimen I-1046), and 7660 ± 300 years ago (U.S. Geological Survey specimen W-1180). Prismatic blades from 2 to 12 centimeters long, polyhedral cores from which small blades have been struck, core tablets, retouched blades with chipping on one

surface to form scrapers, knives, gravers, and burins, and many refuse flakes make up the bulk of this industry (*8*) (see Fig. 1). In this unifacial industry, imported obsidian, greenstone, cherts, and other siliceous, fine-grained stone were used. The obsidian apparently came from the Cape Chagak region (chagak is the Aleut word for obsidian) on the north end of Umnak Island, probably the only source of obsidian in the Aleutians. Who made these blades and what they were used for can only be inferred in the absence of human skeletons and faunal remains. However, the location suggests a marine economy. R. F. Black, who is currently investigating the geology of this area, has noted that, whereas a 10-meter depth of ocean now separates Anangula from Umnak, this area would have been dry land 8000 years ago, and that 12,000 years ago Umnak was an extension of the Alaska mainland, having formed, in fact, the end of the Alaska Peninsula and the southern corner of the old Bering Platform. Early migrants from Asia could have walked along the southern edge of the platform and reached the world's richest hunting ground without losing contact with the sea upon which they depended for their principal food supply. St. Lawrence Island, Nunivak, and the Pribilof Islands, like Umnak and Anangula, are remants of the higher hills on this now submerged platform. The pass (now the strait) that separates Umnak from the Islands of the Four Mountains was never closed during the Pleistocene. People living on the Umnak-Anangula corner of this platform could hunt the annually migrating whales and fur seals, as well as the resident sea otters, hair seals, and sea lions. The founders of Anangula may have been a migrant Bering-platform population who reached the site on foot (see Figs. 2 and 3).

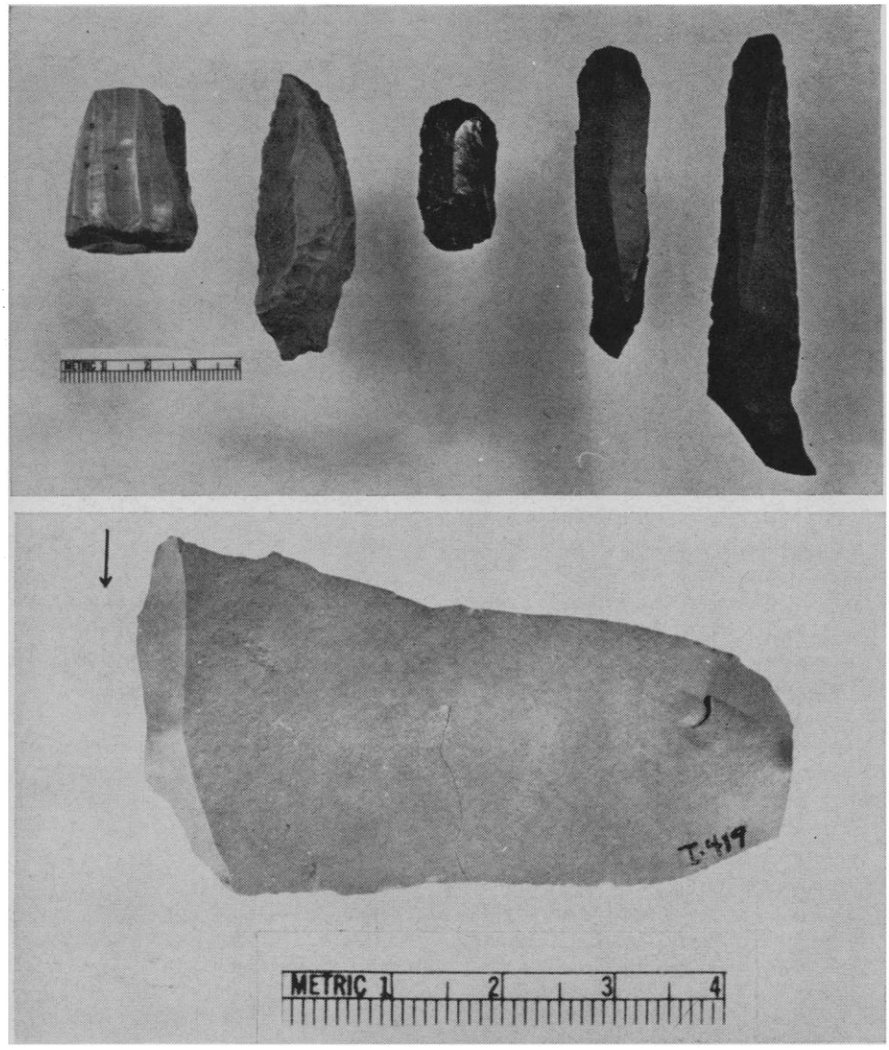


Fig. 1. Anangula core and blades. Eight thousand years ago, when Anangula was a portion of Umnak Island, its inhabitants struck microblades from polyhedral cores and also made larger prismatic blades. The pointed blade (top, second from left) is an "Aleutian graver," presumably used for incision. The blade (bottom) with the transverse flake scar is a burin. This industry is similar to industries in northern Japan 9000 to 13,000 years ago.

Continuity with the village site of Chaluka is suggested by the presence of unifacial tools fashioned on lamellas or prismatic blades. A similar manufacturing technique and similar materials are involved, though the polyhedral cores have not been found at the Chaluka site. The frequency of occurrence of lamellar tools declines rapidly from the bottom level to the top of the Chaluka site, and the frequency of occurrence of obsidian and greenstone declines as well (*9*); these matters were defined more fully by the 1962 excavations of C. Turner, G. Boyd, A. McCartney, L. Lippold, and J. Aigner.

This true core and blade industry is more like the lamellar industries in Japan and Siberia between 9000 and 13,000 years ago than like the somewhat later Denbigh Flint complex of Norton Sound (*10*). M. Yoshizaki, who has excavated at Anangula with McCartney and R. Nelson, suggests that the Anangula materials are most like the tools of the Sakkotsu microblade industry of Hokkaido, the Araya site on Honshu, and the Budun site in Siberia. They seem more clearly Asiatic than tools of the Arctic small-tool tradition, which extended over much of Alaska and provided the base for the Dorset culture of the eastern Canadian Arctic and related cultures of Greenland (*11*, *12*). Both Irving and Yoshizaki place them, with confidence, in a separate province from tools of other Alaskan industries, though there are some similarities to materials of the Campus site at College, Alaska. I infer that the bone artifacts occurred in approximately the same proportion and were of approximately the same kind as those associated with the lamellar tools in the lowest levels of Chaluka, and that the Anangula industry was that of a marine-based people similar to the Paleo-Aleuts of 4000 years ago, a long-headed Mongoloid group. American Indians of comparable antiquity, proto-Mongoloid in appearance, have already been found thousands of miles to the south.

Chaluka

Four thousand years of continuous history are lavishly illustrated in the deep, stratified village site of Chaluka, which now forms the southern margin of Nikolski, a village of some 55 Aleuts. This is one of the few sites in the Arctic or subarctic which contains the requisite materials for interdisciplinary study of evolution, prehistory, and ecology: human skeletons, abundant artifacts, and remains of buildings and of faunas, all superimposed in such a way as to provide a record of several thousands of years of events in one place and evidence of a connection with the living inhabitants. The reasons for the long-term occupation of this site are apparent. There were fresh-water lakes, vital for spawning salmon (these lakes may not have existed at the time of initial occupation); an enclosed bay with front reef, which provided protected waters for fishing during storms at sea; large reefs, exposed at low tide, which were rich in invertebrates such as sea urchins, mussels, whelks, limpets, and chiton and in edible seaweeds, kelpfish, and octopus; offshore rocks and islands that provided cliffs for nesting cormorants and puffins, where they were protected from foxes (the Aleuts ate the eggs of these birds); a complex coastline which trapped driftwood, dead whales, and dead sea lions and provided diverse ecological niches attractive to sea otters, which like to live in extensive kelp beds. Cod and halibut could be caught from the shore, as well as from boats in the channels and pockets. This site is on a 10-meter beach of the postglacial thermal maximum and thus cannot be older than 5000 years; the water level has probably changed very little during this period. The oldest date obtained by the radiocarbon method, 3750 ± 180 years, is for a sample found above the sterile floor (*13*), and an age of 4000 years has been proposed for the site, on the basis of the lower limits of seven dates obtained by this method.

The earliest Paleo-Aleuts of the Chaluka site used stone lamps, various kinds of harpoons and spearheads, fishhooks, unifacial (lamellar) tools, and ivory and bone labrets for lip decoration. Adze bits and whalebone wedges are evidence of a wood-working industry. Distinctive harpoon heads are fluted or channeled (Fig. 4) and slotted to receive straight-based bifacial chipped stone points. Stone points have been found embedded in sea lion bones

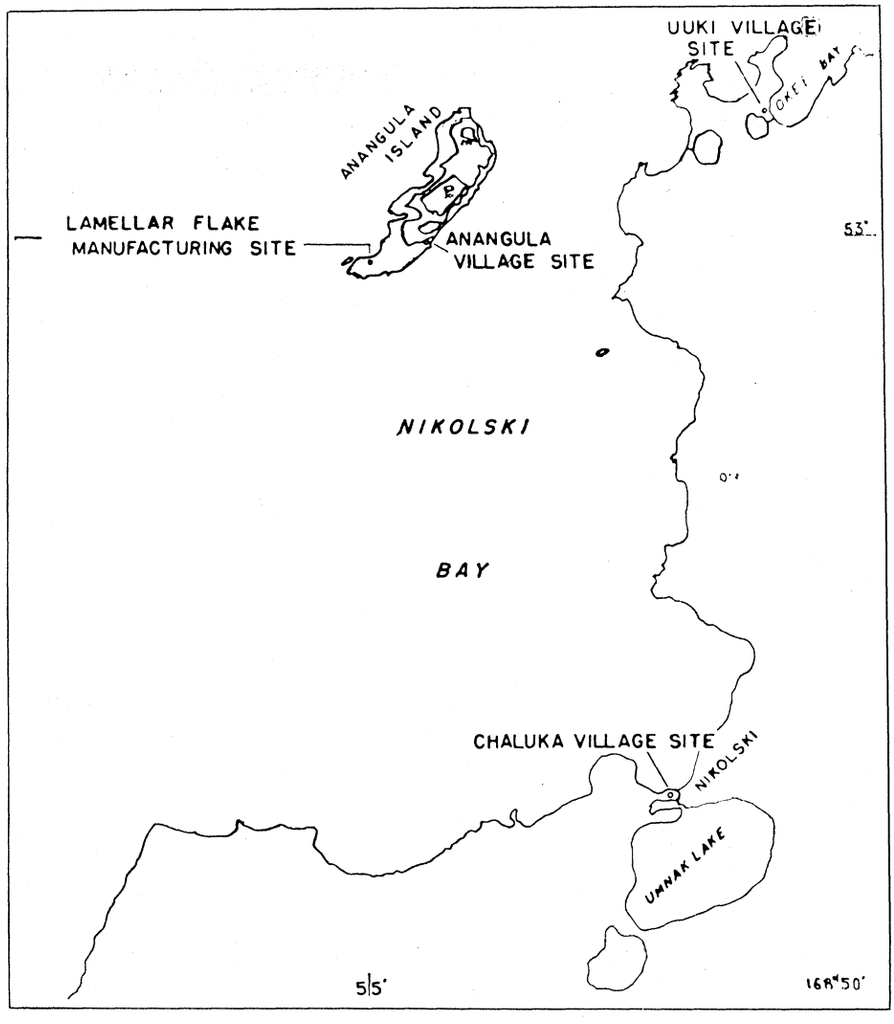


Fig. 2. Map of Anangula Island and Nikolski Bay (scale: 1/40,000).

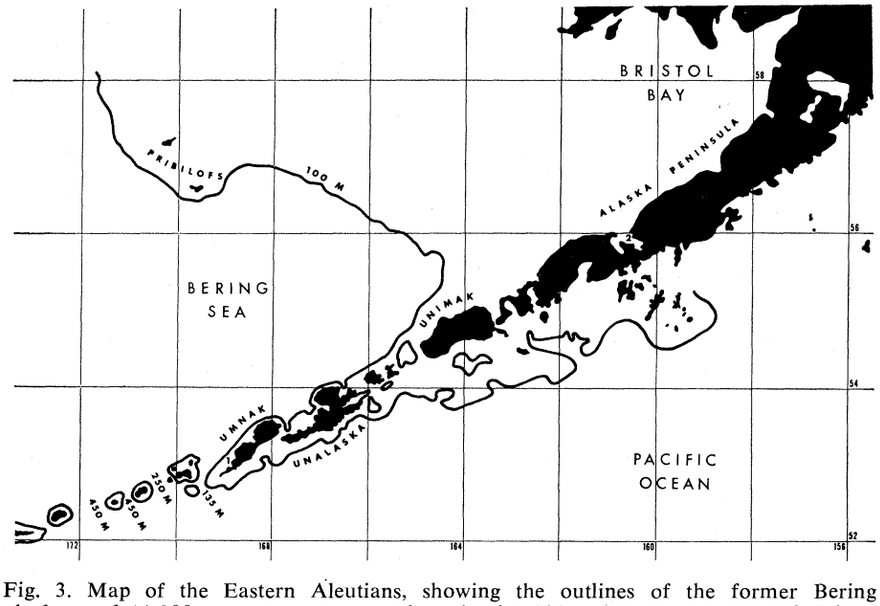


Fig. 3. Map of the Eastern Aleutians, showing the outlines of the former Bering platform of 11,000 years ago at approximately the 100-meter contour. Umnak Island was then the terminus of the Alaska Peninsula. The passes west of Umnak are too deep for a land bridge to have formed at any time during the last glaciation as a result of lowered water levels. Presumably, early populations lived on the platform and withdrew as the water level rose. 1, The Chaluka-Anangula area. 2, Port Moller, the point of division between Aleuts and Eskimos. [Courtesy of R. F. Black.]

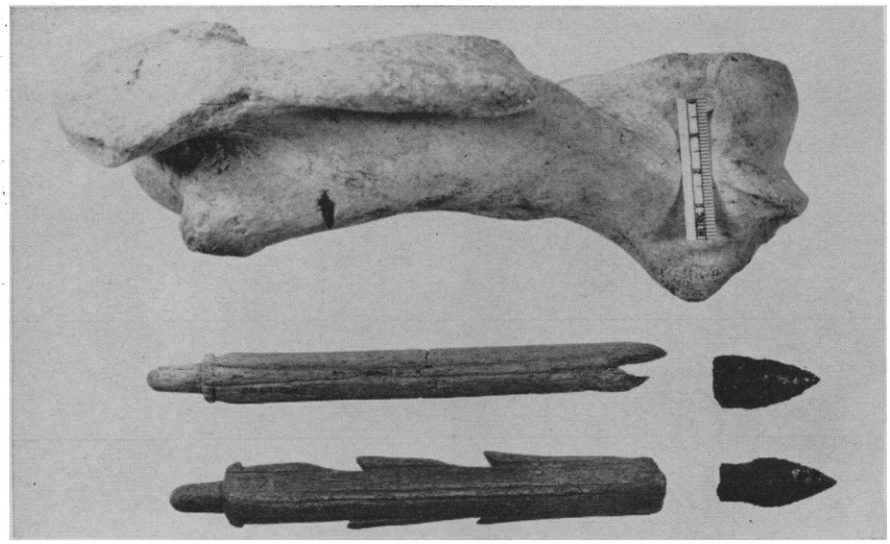


Fig. 4. (Top) Sea lion humerus, from the lower levels of Chaluka, with a stone point embedded in it. Detachable whalebone harpoon heads of this type were used for some 2000 years or more. (Middle and bottom) Early Aleutian harpoon heads with slots in the end for inserting chipped stone points.

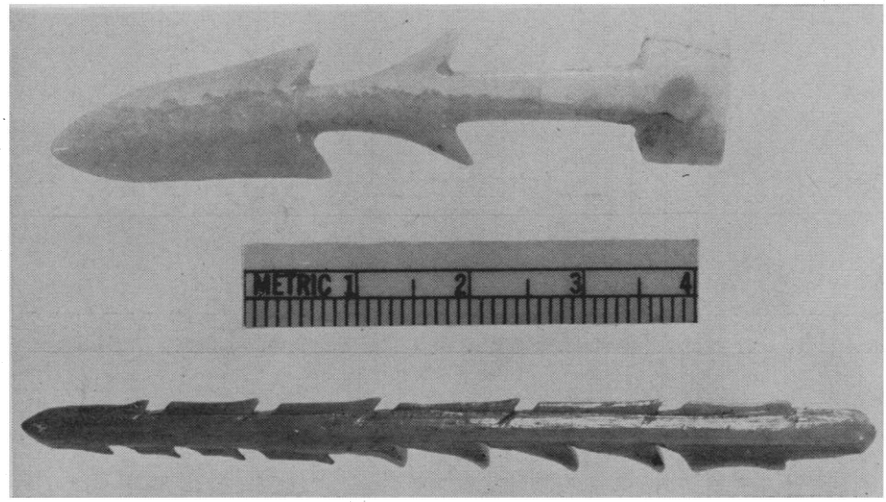


Fig. 5. (Top) Harpoon head of a very late type, made of ivory and used by the Umnak Aleuts for hunting sea otter. (Bottom) Chaluka harpoon head of an early, fluted type (about 3000 years ago), made of ivory and suitable for hunting small sea mammals such as sea otters, female fur seals, and harbor seals.

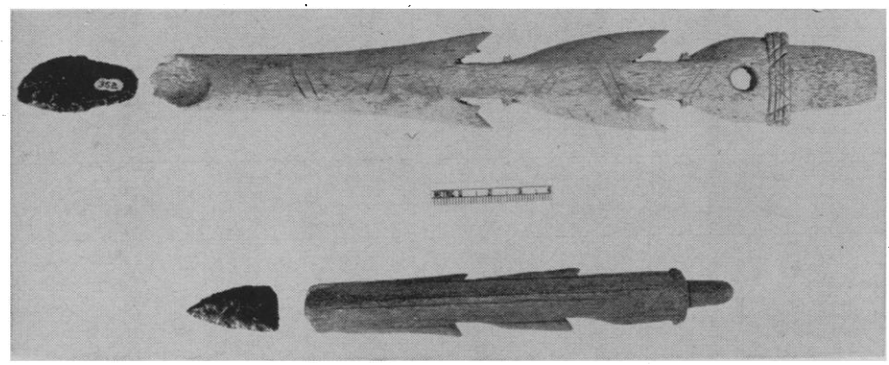


Fig. 6. (Top) Harpoon head of recent type, in use at the time of the discovery of Alaska by the Russians, in 1741. In contrast to the head of an earlier type (bottom), the chipped-stone end point has a round base and is inserted into a basin on the side of the whalebone head. A harpoon head of this type was inserted into a two-piece socket and lashed to a wood shaft for use as a spear or lance in hunting humans. It was supposedly long enough to penetrate a man's chest and to his spine.

in these strata. The elaborate carving of harpoon heads with circle-dot-and-line designs shows great artistry. The incompletely excavated foundations of houses indicate that these were oval, with coursed masonry; that one entered from the side; that there was a slab-lined hearth; and that ribs and mandibles of whales were used for rafters.

The artifacts in the upper levels include many tools and objects needed for life in a subarctic, marine environment, but none of these represent basically new categories, with the possible exception of barbs for fish spears. Many new types do appear. Two-piece bone sockets to receive long harpoon heads with stone points inserted in a basin rather than a slot are found, still in association with Paleo-Aleut skeletal remains. The forms of fishhook shanks change. The older, elbow shank carved from whalebone is replaced by a curved shank carved from sea otter rib. In general, the artifacts at various levels are of the same categories: lamps, root diggers, splitting wedges, bird-spear side prongs, labrets, weights for fish lines, chipped stone knives, and flaking tools. Recently (only a few hundred years ago at most) four variations appeared at Chaluka: ground-slate ulus, shallow soapstone lamps, single-piece sockets to receive small barbed ivory harpoon heads used in hunting small mammals (see Figs. 5 and 6), and a group of artifacts, including hats, that have been found in mummy caves. The Neo-Aleut skeletal type is associated with these recent artifacts, and this association poses the problem of rapid internal change versus migration.

There is no single change in kind or category of artifact over 4000 years that appears to have made a detectable change in the system of adaptation or in the way of life. While it is entirely possible that such fundamental changes did in fact take place, it is significant that, despite sensitive excavation techniques and the recovery of large numbers of artifacts and faunal remains and of human skeletons in sufficient numbers to show how the people lived, what they lived on, and how they buried their dead, no major change is detectable. The later, bifacial tools have no obvious advantage over unifacial tools. Line holes in a few harpoon heads of the lowest levels are gouged out rather than circularly drilled. Such traits may be important time markers, but they have little significance from the standpoint of adaptation.

Faunal Remains

The faunal picture at the Chaluka site explains the rise of a large population in this area and the use of many tools. W. G. Reeder has sketched the basic relations between mammals, birds, fish, and invertebrate remains and is relating these to modern communities. As Scheffer has noted (*14*), "There are in fact no small marine mammals of any kind." Large marine mammals were available, and thus the Eskimos and Aleuts had an unusually rich source of food. In addition, their social habits and their numbers assured them a good food supply. Eskimo culture is primarily adapted to marine hunting but is sufficiently flexible to include means of hunting land animals as well.

The principal faunal remains excavated in 1962 (except for invertebrate remains) are shown in Table 1. The pinnipeds include harbor seals, fur seals, and sea lions. Though Aleuts on the Alaska Peninsula secured important numbers of walrus, sea lion remains are found more often in the Aleutians. More of the sea lion than of the seal skeletal remains are adults. This may reflect the selective use of hides of mature sea lion for making umiaks and kayaks, and the use of sea lion flippers for boot soles. The fur seal now migrate through the Aleutian straits to the Pribilof Islands, some 400 kilometers north of Umnak. Since they do not ordinarily haul up on beaches while in transit, it is probable that they were killed at sea from boats.

Cod and halibut are the principal fish represented in the 1962 excavations, the cod constituting some 80 percent of all the fish remains. Salmon are poorly represented—a finding which suggests that the great salmon runs of the last several hundred years had not started 4000 years ago. Among the bird remains in these deposits, cormorant remains are the most common, with puffin and duck remains less frequent. Albatross remains occur at all levels, perhaps in somewhat greater number at the lower level. Either the habits of the albatross have changed and they formerly nested on Umnak Island, as claimed by Chamisso, or they were hunted down at sea. Sea urchin remains make up a large part of the deposits; apparently the sea urchin was the basic invertebrate in the diet, as the sea otter was a basic vertebrate. The importance of the sea urchin cannot be overestimated. Women, disabled men, and chil-

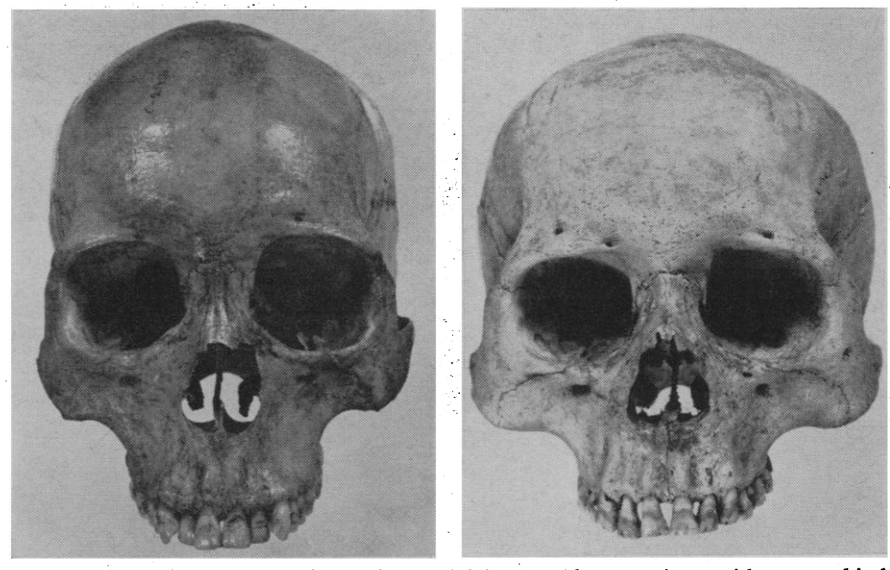


Fig. 7 (left). Paleo-Aleut cranium. Fig. 8 (right). Neo-Aleut cranium, with supraorbital foramina instead of notches, an accessory supraorbital foramen, large infraorbital foramina and an accessory infraorbital foramen, and an accessory zygomaticofacial foramen. Mongoloids characteristically have large or accessory foramina.

Fig. 9 (left). Paleo-Aleut cranium (side-view). Fig. 10 (right). Neo-Aleut cranium (side view). Crania of Neo-Aleuts are among the lowest and most capacious in the world.

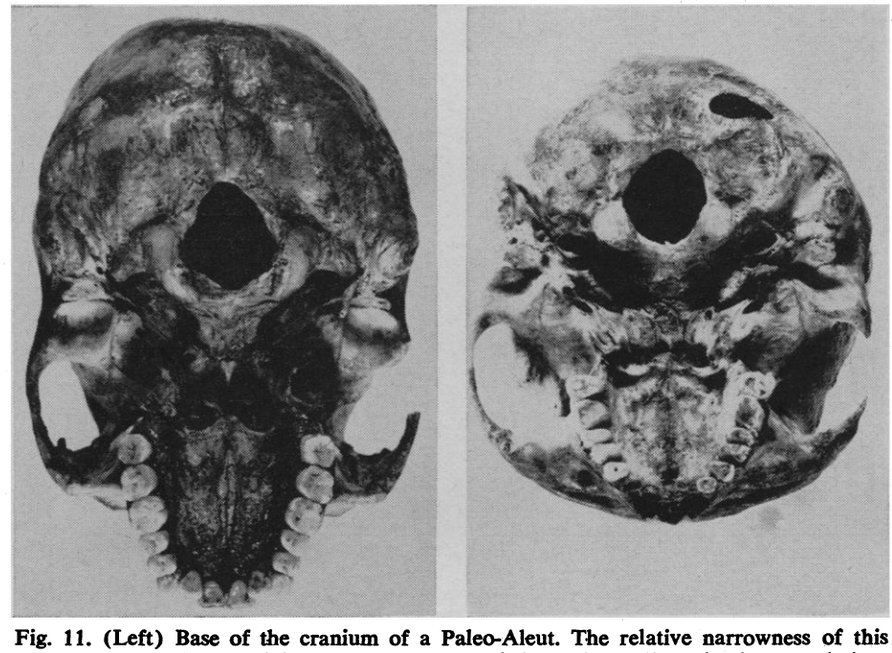


Fig. 11. (Left) Base of the cranium of a Paleo-Aleut. The relative narrowness of this cranium and the long occipital area are characteristic of the earlier Aleutian population. (Right) Base of the cranium of a Neo-Aleut. The great breadth of this cranium and the short occipital area are characteristic of individuals of this more recent population.

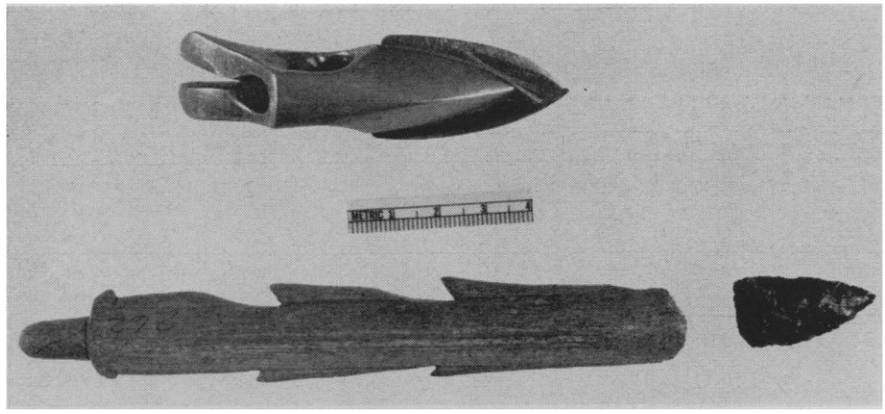


Fig. 12. (Top) Modern toggle-head harpoon (for hunting walrus), made of metal by the Aivilik Eskimo, Southampton Island, Canada. Since the sea mammal is retrieved by means of a line attached to the harpoon head, the continuing use of harpoons, along with rifles, is assured, for rifles kill but cannot retrieve. (Bottom) Early Aleutian fluted harpoon head with inset stone point, used for hunting large marine mammals such as sea lion. The detachable head remains in the body of the mammal but does not turn at right angles to the line as the toggling harpoon head does.

dren could gather sea urchins and other invertebrates during the spring, when other food sources were depleted. Thus, starvation was avoided in many communities. The contrast between this situation and that in the central Arctic, where the inhabitants were unable to get food from the sea because of the impenetrable ice barrier, is reflected in the population profiles. The economic productivity of children, disadvantaged women, and elderly or disabled men is a major factor in community adaptation, with both genetic and cultural consequences.

The human skeletons (Figs. 7–11) indicate an evolutionary change in all of southern Alaska—a change in head form from dolichocranial (breadth less than 75 percent of length) to brachycranial (breadth more than 80 percent of length). There are also changes in the occurrence of dental cusps and mandibular tori. One Paleo-Aleut found at the bottom of the Chaluka site displayed vault thickening (hyperostosis cranii) characteristic of some anemias. All the skeletons found in the eastern end of the Chaluka site, with the exception of recent burials, belonged to the long-headed (dolichocranial) Paleo-Aleut type. The most recent inhabitants—those whose remains are associated with knives of ground slate, with shallow stone lamps, and with single-piece sockets and short harpoon heads—are extremely broad- and low-headed. Hrdlicka, who was the first to note that there were two physical types, one of which succeeded the other stratigraphically, termed the earlier type "pre-Aleut" and the later type "Aleut" (*15*). Marsh and I suggested the terms "Paleo-" and "Neo-Aleut" for the physical populations, to indicate the continuity and similarity, and the possible evolution of the later from the earlier population (*16*). Dental studies (*17*) and anthropometric studies of living individuals (*18*) establish a continuity between the most recent skeletons in Chaluka and the present-day inhabitants. Some characteristics of the earlier population appear in the western Aleuts. They are more narrow-headed than the eastern Aleuts, and they differ from them in frequency of occurrence of discontinuous traits. The pressing problem now is that of securing enough skeletons from stratified and dated sites to confirm this apparent evolutionary change and to provide a basis for estimating the rate of change, as well as its extent. Parallel changes on Kodiak Island and along the Kuskokwim River indicate that there was both internal evolution and migration (*19*, *20*).

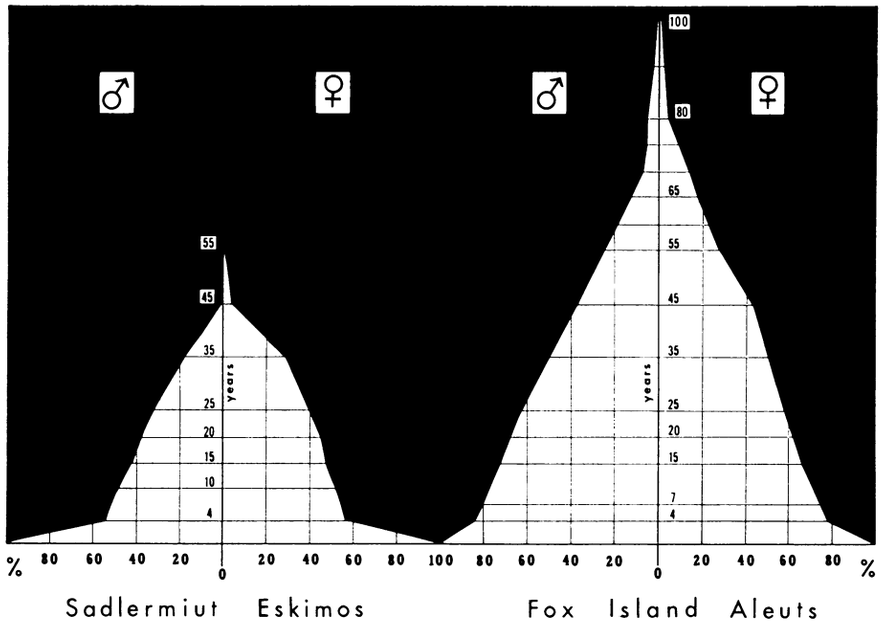


Fig. 13. Data on age at death of the Sadlermiut Eskimos of Southampton Island, Canadian Arctic, and Aleuts of the Fox Island district in the eastern Aleutians. The Sadlermiut Eskimos died relatively early in life as compared with these Aleuts. Infant mortality was also greater under the more stringent conditions of the arctic environment.

The record for 4000 years of prehistory in the Chaluka site demonstrates that the styles of artifacts change more rapidly than ecological circumstances. The artifacts (harpoons and spears in particular) were necessary for hunting marine mammals, but the particular forms varied considerably. It apparently made no difference, either to the sea lion or to the hunter wielding the harpoon, whether the harpoon had a fluted, stone-tipped head or a four-barb whalebone head. Cod and halibut were caught equally well with an elbow-shank fishhook and a curved-rib-shank fishhook. The 16,000 Aleuts discovered by Bering and Steller in 1741 were adequate evidence of the faunal wealth of the Aleutians and of the efficiency of their system of exploitation.

Bering Strait Sequence

The time depth for Eskimo sites decreases as one proceeds from southwestern Alaska to the Bering Strait region. Prior to 2000 B.C. the Bering Strait cultures are represented primarily by lithic industries and yield little information about the way of life or the racial characteristics of the people. Giddings has drawn attention to the persistence of tradition in the constituent areas: the Asiatic, Chukchi Sea, and Bering Sea areas. One site in particular is comparable to Chaluka; this is the great Kukulik mound of St. Lawrence Island, which shows continuous occupation from Old Bering Sea II times (about A.D. 300) to 1884. Walrus hunting, sealing, and whaling have been of continuing importance and, interestingly, the artifacts used in these activities show only a slow change in style and a gradual loss of the art of engraving over 2000 years. As Giddings comments (*10*), "No basic change appears abruptly in the pattern of subsistence, and only a few exotic elements were introduced before the coming of Europeans." The significance of this continuity and stability in these three Bering Strait areas for studies of evolution lies in the indication that there has been little real migration of groups. It may be that many of the later physical variations are due, rather, to internal changes, with gene flow resulting from exchange of mates across the boundaries of isolate groups making a relatively small contribution.

Important to an understanding of the early interconnections between Mongoloids in the Eskimo-Aleut area as a whole is recognition that early cultural traditions were more widespread than the relatively localized cultures of the last several hundred years. Of critical importance is the Arctic small-tool tradition, defined by Irving, which provided roots for the development of the pre-Dorset and Dorset cultures of the eastern Canadian Arctic and Greenland (*11*, *12*, *21*). This tradition, which includes the Denbigh Flint complex, is characterized by large numbers of microblades struck from conical polyhedral cores and by burins, retouched burin spalls (also used as engraving tools), small bifacially retouched blades for insertion in the sides of harpoon heads, and medium-sized (4 to 10 cm) biface points and knife blades (*11*). This tradition appeared in Alaska and Siberia as early as 6000 years ago, and reflections of it reached the Canadian Arctic and Greenland very early. Collins, who initiated the early work on St. Lawrence Island and continued his investigations across the Arctic, points out that the Arctic small-tool tradition is "pre-Eskimo" but that the prefix *pre* in this case connotes "predisposed" or "leading up to" (*12*). Thus, the evidence, though meager, indicates that the people of the Dorset culture were Eskimo in their morphology (*22*).

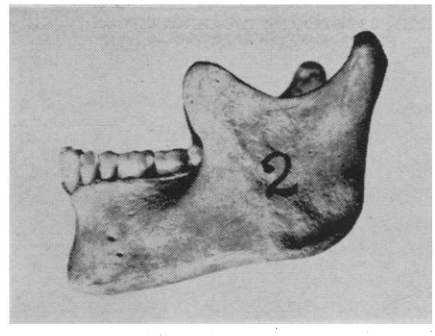


Fig. 14. Mandible of a man of the Okhotsk culture, Hokkaido, Japan, about A.D. 1000. The enormously broad ascending ramus is characteristic of many Mongoloid groups. The breadth of this feature in Eskimos and Aleuts exceeds the breadth in Neanderthal man. There are multiple mental foramina in the region of the chin. [Specimen courtesy of Kohei Mitshuhashi, Sapporo Medical College]

In general, the more northern cultures used the toggle-head harpoon more often than the harpoon with a simple detachable head that is used in southern Alaska. Toggle-heads presumably turn inside the animal with tension on the harpoon line (Fig. 12). (Much the same effect is produced with multibarbed, detachable harpoon heads, especially those that are asymmetrical.) These harpoon heads are indispensable time markers, just as pottery is in the southwestern United States. They are more closely related to the way of life than pottery is, but there is still by no means a one-to-one correspondence. Other general characteristics of the northern cultures are their greater use of the umiak and their custom of hunting on the ice, with the sled drawn by dogs. Kayaks were inevitably more important in the south, where there is more open water. Hunting from kayaks has many advantages: kayaks provide speed and a means of rapidly scanning complex coastlines. Moreover—and this is extremely important—the kayak does not have to be fed! The Aleuts and Koniags developed the kayak to a higher degree than any other members of this stock, and much of the material culture reflects the elaboration of open-sea hunting of mammals.

Adaptation to Cold and Glare

A common misconception about Eskimos is that they are fat or chubby. Measurement of the thickness of skin folds confirms the observation that they are in fact lean. Though muscular, with heavy bones, they have little fat even at advanced ages. They are medium-to-short in stature, with long trunks and short legs. The lower leg is particularly short. Their heads are large, and their hands are small-to-average in size. When they are fully clothed for protection against dry cold, only a portion of the face is exposed. Possibly the large face with broad jaws and the bulky clothing have contributed to the notion that they are fat.

Thermoregulation in the Eskimo is characterized by basal metabolism that is higher than clinical standards for normal metabolism and high in view of the lean body mass. When the Eskimos are fully clothed they are living in a tropical microclimate in which sweating accounts for most dissipation of the excess metabolic heat. F. Milan has found that Eskimos maintain their warmth even while lying on the winter ice, hunting seal. They probably have more sweat glands than members of other races, but too few counts have been made to confirm this. Blood flow to the hands and legs is greater

Table 1. Preliminary summary of data for excavated bones, Chaluka, 1962. [L. Lippold, G. Streveler, and R. Wallen]

Layer	Bones (No.)	Bones (%)				
		Bird	Fish	Pinniped	Sea otter	Cetacean
Upper I	3,626	27.8	44.2	20.4	6.8	2.0
Upper II	5,906	15.2	50.6	25.8	5.8	2.2
Upper III	10,858	19.6	7.3	47.0	25.3	0.1
Lower IV	1,127	29.8	13.3	39.8	16.6	.4

when the limbs are cooled in water than it is in normal white controls. The perception of pain resulting from cold appears to be less acute in both children and adults than it is in other races, and the Eskimos have higher finger temperatures during cooling in cold air (*23*).

Equally important in the adaptation to cold have been the material culture of the Eskimos and the Aleuts and the child-training practices. The ordinary clothing includes undergarments, pants, boots, mittens, and parka with ruff. Where hunting is done from kayaks, the clothing is made of waterproof materials, such as the esophagus of hair seal or sea lion and the intestines of various mammals, such as whales, walrus, or seals. Parkas made of the skins of birds—cormorants, puffins, and auklets in particular—are used in all areas. Insulative materials such as dried grass and caribou skin are worn inside boots.

Glare from water, ice, or snow is minimized by the use of slit goggles or visors. In the Aleutian Islands and in southern Greenland, kayakers habitually wore visors or shades for protection against spray and glare. Eskimos who use sleds wear slit goggles instead of visors.

Selection for cold-adapted individuals has probably been extensive in the southern area, where there is greatest use of the sea. Heat loss is so greatly accelerated in cold water that a victim who has been immersed for a few minutes often cannot be saved even by rapid rewarming techniques. Ability to withstand wet cold for even a few additional minutes has often meant rescue by another hunter. On land, by contrast, a fully clothed person can survive many days of extreme cold. No studies on the heritability of resistance to cold have been made. There is no experimental evidence to suggest that the Mongoloid face, the long trunk, and the short legs are characteristics that have developed as a result of the climate.

Longevity

A critical variable, about which reliable information is slowly being accumulated, is that of age at death. In this respect there are large contrasts between isolates, with ascertainable genetic and cultural consequences. In general, it appears that the people who lived in the more harsh arctic environments died earlier. Those who inhabited ecologically richer areas—subarctic and more ice-free areas—lived much longer. A sharp contrast, for which the

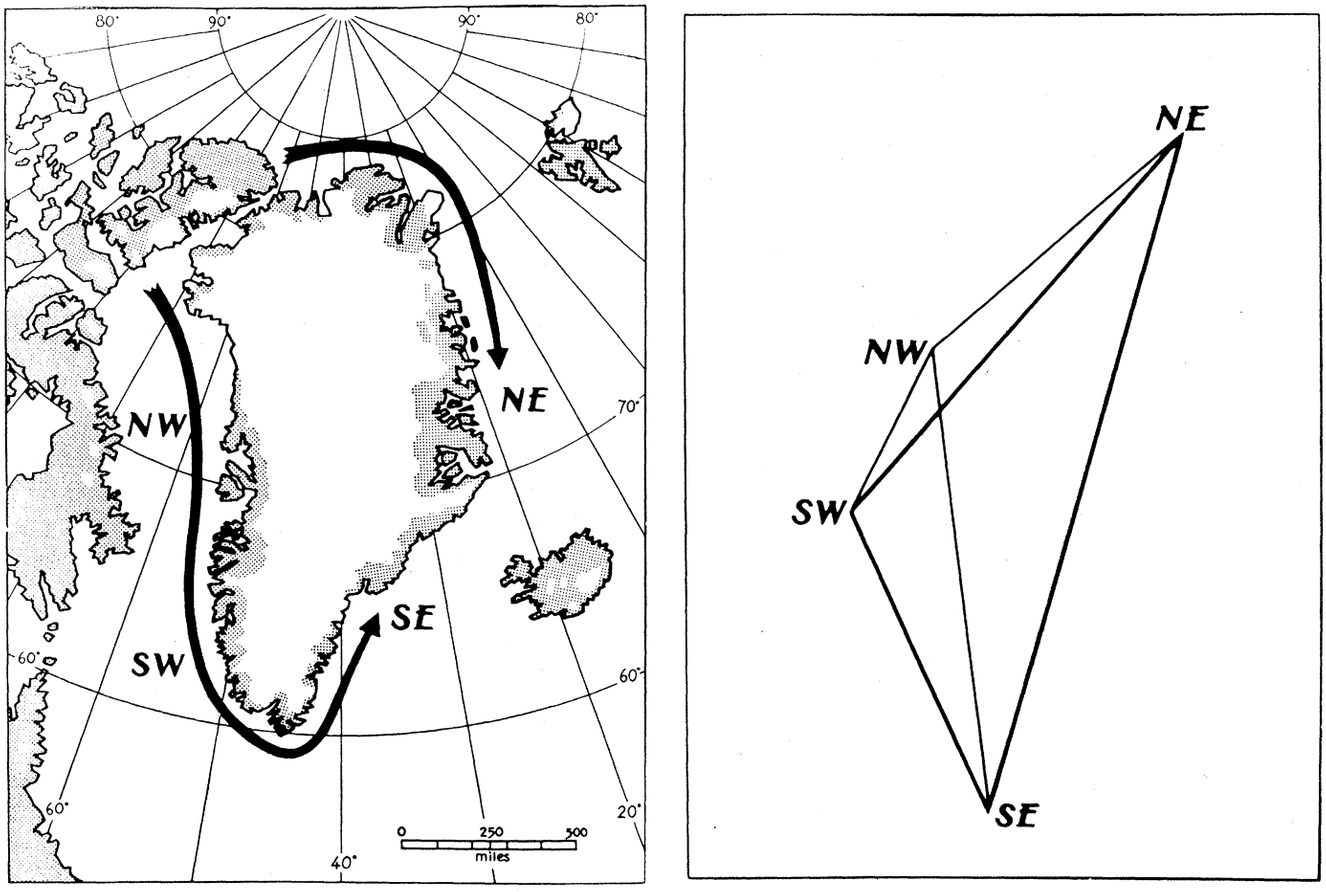


Fig. 15 (left). Migration of the Eskimos about Greenland. The migration was confined to the coasts because of the inland ice. It moved in two directions, with the result that the terminal isolates (the Northeast and the Southeast), separated for the longest period, show the greatest morphological differences. Fig. 16 (right). Geometric representation of the relative degrees of similarity between the four Greenlandic Eskimo isolates. The difference between the Northeast and the Southeast isolates is greater than the difference between any other two contiguous isolates. Though geographically as far apart as the Northeast and Southeast isolates, the Northwest and Southwest isolates exchanged mates more frequently and are much more similar to each other. [Courtesy of L. S. Penrose (*43*)]

Table 2. Frequency (in percentages) of discontinuous cranial traits in Greenlandic Eskimo isolates. The percentages, based on a total series of 293 male skulls that J. B. Jørgensen and I studied in the Laboratory of Anthropology, University of Copenhagen, provide the basis for estimating similarity, as illustrated in Fig. 16.

Trait	North-west	South-west	South-east	North-east
Dehiscences	26	32	19	26
Parietal notch bone	22	21	17	14
Supraorbital foramina	60	58	59	48
Mandibular torus	69	65	44	90
Palatine torus	36	32	24	9

cultural context is known, is that of the extinct Sadlermiut Eskimos of Southampton Island (Northwest Territories), in the northern part of Hudson Bay, who died at a much earlier age than their Aleut counterparts in the eastern Aleutians. The Sadlermiut numbered about 57 at the time they became extinct, in 1903. The Unalaska Aleuts (from the Fox Island district), already decimated by disease and massacre, numbered some 1500 between the years 1825 and 1835. Their chronicler, I. Veniaminoff, reported age at death for 491 Aleuts (*24*). These ages are therefore directly comparable with ages at death estimated from the skeletal remains of the Sadlermiut. As Fig. 13 shows, the maximum age at death among the Sadlermiut was between 50 and 55 years. In marked contrast, the maximum age at death among the Aleuts was between 90 and 100.

Age at death affects not only such things as disease patterns but the genetic composition and cultural complexity of the group as well. There is more wastage in the group in which a higher percentage of the offspring die before the age of reproduction, and each generation is a less adequate sample of the preceding generation. Age at death is closely correlated with population size, and this in turn is correlated with the ecological base and the technological system.

The cultural consequences and the biological consequences may be considered separately for purposes of analysis. The greater overlap between generations associated with greater longevity provides more time for transfer of information. The experience of older people is stored in accessible form for a longer period in more "storage cells." The florescence of medical and anatomical knowledge among the Aleutian Islanders indicates a specific form of feedback. Difficult deliveries could be successfully managed because of the presence of old and skilled individuals (*25*), and treatment of serious injuries enabled the injured individual to participate in group life, if not in active hunting, on his recovery. Artistic expression and the larger number of public ceremonials and myths are among the correlative benefits of greater longevity and greater population.

Various patterns of pathology are characteristic of the Eskimos and Aleuts, and in some of these conditions there is probably a high element of heritability. Spondylolysis of the lumbar vertebrae is especially common (*26*). Developmental anomalies such as premature or irregular closure of cranial sutures are also common. Arthritis occurs frequently, and there is an interesting sex difference: in arthritis of the elbow, arthritic lesions occur much more frequently on the capitellar surface of the humerus in males and on the trochlear surface in females.

Blood-Group Evidence of Origins

The blood-group data, in addition to their value in studies of population genetics of small isolates, throw much light on Eskimo-Aleut affinities and origins. They show that the members of this stock are clearly distinguished from American Indians and more similar to Asiatic Mongoloids. The percentage of blood type B in Eskimo-Aleut isolates ranges from 2 to 26, whereas in American Indians it is zero. The percentages in Asiatic Mongoloids are the highest in the world; those for the Chukchi (the lowest in the Asiatic Mongoloid group) are a little higher than the average for the Eskimos (*27*). Indians who live in contiguous areas —the Tlingit, Athabascan, and Algonkin—have no gene for blood group B. The percentage of group B is especially low among the Eskimos of the central Canadian Arctic. Chown and Lewis (*28*) have suggested that this indicates a Dorset-culture residuum. Traces of earlier peoples should show through more frequently in areas of low population density, or in areas where the earlier population made a large contribution to the newer population, as in the western Aleutians. North American Indians have genes for blood groups A and O, and as in all Eskimos and Asiatic Mongoloids, the A is of subdivision A_1. Though Alaskan Athabascan Indians are low in group A, the highest frequencies of group A in the world are found among the Blood and Blackfoot Indians of Alberta and Montana.

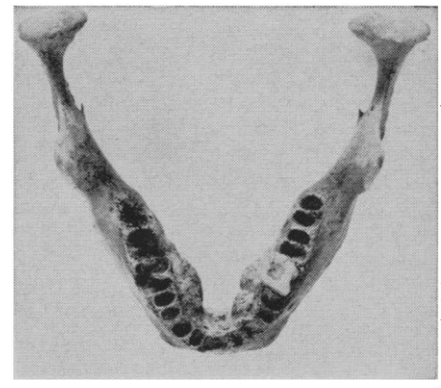


Fig. 17. Eskimo mandible with mandibular torus—the bony mound on the lingual surface. A form of this torus is found in *Sinanthropus pekinensis*. In Eskimos and Aleuts the number of mandibular tori exceeds the number of palatine tori; the converse obtains in American Indians and Europeans.

An interesting cline shows the distribution of the frequencies of blood type MNSs. Chown and Lewis found the occurrence of type MS higher in the Copper Eskimos of the central Canadian Arctic and lower as one proceeds to the southeast. Significantly, as the Eskimos approached the Indians

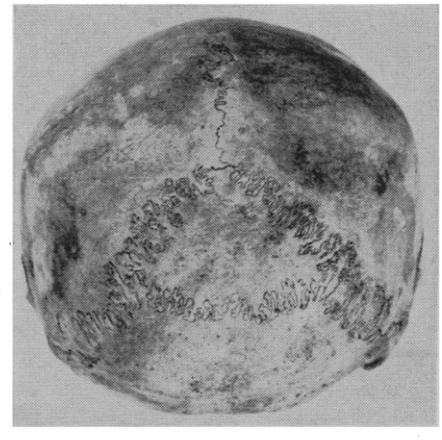


Fig. 18. Inca bone in the occipital bone of the cranium of a Neo-Aleut. A horizontal suture separates the upper portion of the occipital into a triangular portion. This is found in *Sinanthropus pekinensis*, Mongoloids, and American Indians in varying but often high frequencies.

geographically they became genetically more dissimilar (*29*).

Eskimos lack the Diego factor, which is found in highest frequency in Venezuela and reappears in Asia. All Eskimos secrete blood-group substance in their saliva, but many are nontasters of phenylthiocarbamide (PTC), in contrast to Indians, among whom tasters of PTC are fairly numerous. The Rh chromosomes R_1 and R_2 are common, and similarities between Aleuts and Greenlandic Eskimos are marked (*30*). Both differ from Indians in having low rates of excretion of β-aminoisobutyric acid and a low incidence of haptoglobin type 1-1 (*31*).

Discontinuous Variation

The component isolates and populations of the Eskimo-Aleut stock are self-defining in that they are breeding isolates. They generally choose their mates within their own groups. Eastern Aleuts mate with eastern Aleuts and Polar Eskimos mate with Polar Eskimos, through preference and because of proximity. These groupings exist, regardless of whether we choose to recognize or classify them. The Polar Eskimos are a classic example of a geographically isolated breeding isolate. When they were discovered, in 1818, they thought they were the only people in the world. In addition to cultural and geographic barriers to mating—that is, to gene flow across isolate boundaries—the factor of relative population size has played an important role in minimizing the effects of mixture between Eskimos and Indians. The size and density of the Eskimo populations provided genetic insulation against the smaller groups of contiguous Indians. The physical traits which characterize isolates may be divided into those which vary continuously (stature, intermembral proportions, size of the ascending portion of the mandible) and those which are discontinuous or not present in all the people (particular blood groups, fissural patterns on the teeth, various foramina and sutures) (see Fig. 14).

Table 3. Frequencies (in percentages) of discontinuous traits in distantly related races. The relatively large differences between (i) Norse and (ii) Eskimos and Indians and the smaller differences between Eskimos and Indians parallel the anthropometric and serological differences. Caucasoids and American Indians both have an excess of palatine tori over mandibular tori, in contrast to the Mongoloid Eskimos. (No submedium or ambiguous tori are included in these series.)

	Medieval Norse in Greenland		Arikara Indians of South Dakota		Eskimos of Greenland	
	♂ (N=38)	♀ (N=43)	♂ (N=60)	♀ (n=40)	♂ (N=293)	♀ (N=291)
Dehiscences	6	1	29	43	27	36
Parietal notch bone	15	17	10	12	21	15
Supraorbital foramina	16	38	50	59	59	62
Mandibular torus	37	41	0	0	67	47
Palatine torus	59	58	29	44	32	36

Among the continuous traits in Eskimos and Aleuts are the very large cranium, the large flat face, the broad mandible with unusually broad ascending ramus (the mandible is broader in Eskimos and Aleuts than it was in Neanderthal man), and the medium-to-narrow nose. Earlier Aleuts and Eskimos had heads that were narrow in proportion to their length (head breadth is usually less than 75 percent of the length, in cranial series). The greatest head breadth occurs on Kodiak Island, where, among the living, the head breadths are some 86 percent of the head lengths. This value, the cephalic index, decreases both to the west and to the north. Trunks are long and legs are short, though the total height varies. Eskimos in the interior of northern Alaska and Canada are taller than those along the coast (*32*). Interestingly, Eskimos and Aleuts grow over a longer period of time than people of other stocks (*33*).

Although all Greenlandic Eskimos can be characterized as a single group, it is more profitable, in research at the microevolutionary level, to recognize and compare the constituent isolates within Greenland. Findings on variation between breeding groups can then be used for the study of traits as such, for inferring the direction of migration, and for estimating rates of change. Blood type B is rare among the Polar Eskimos, more frequent along the west coast, and most frequent among the Angmagssalik Eskimos of the southeast coast. No blood-group comparison with Eskimos of northeast Greenland is possible, for those Eskimos are extinct. However, in studies based on discrete traits of the skull they can be included, and thus it is possible to draw comparisons among peoples whose migrations were limited to coastal areas because of inland ice. The Greenland Eskimos could migrate only clockwise and counterclockwise, or in both these directions, from a single area of entry, and no mating between isolates on opposite sides of Greenland was possible (see Figs. 15 and 16). If they moved in both directions, the terminal isolates should display the greatest differences (Table 2). Studying eight discontinuous traits observed in some 600 skulls representing four isolates, Jørgensen and I found that the northeast series and the southeast series did in fact show the greatest differences. We inferred, therefore, that the Eskimos migrated in two directions around the coasts of Greenland (*34*). This conclusion is supported by ethnological and archeological evidence. As early as 1909, Boas (*35*), on the basis of similarities between artifacts found in Greenland and artifacts in Canada and Alaska, suggested that a migration movement north around Greenland had taken place. Through measurement of continuous traits, the north-

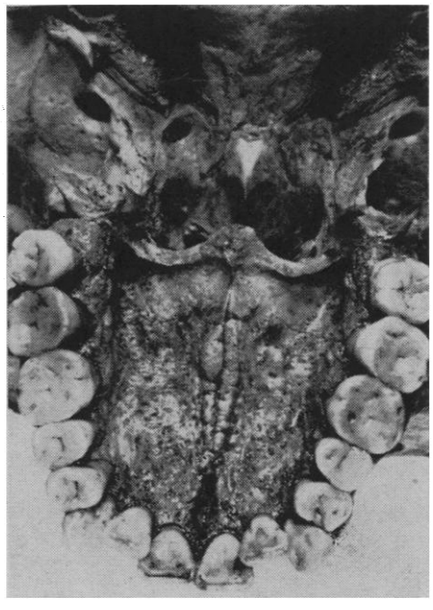


Fig. 19. Palate of the cranium of a Paleo-Aleut, showing the palatine torus, the mound of bone running along the center of the palate, and the shovel-shaped incisors. Marginal ridges on the lingual surface of the incisors create a scooped-out area. These ridges are found in Mongoloids, American Indians, Polynesians, and *Sinanthropus*, and in some members of other races.

east and southeast series have been identified as the terminal isolates. Measurements for the northeast series are the largest in Greenland, and those for the southeast series are the smallest. The cranial samples represent migrations after A.D. 1000 and roughly indicate the extent of differences which may occur between isolates in some 800 years. The southern Norse colony on the southwest coast of Greenland was raided by Eskimos in A.D. 1379, and it disappeared about A.D. 1500. Eskimos who had come from the west coast had been living in southeast Greenland no more than 400 years when they were discovered in 1884.

Differences between more distantly related peoples are larger, as would be expected (Table 3). The mandibular torus (Fig. 17) occurs most often in Mongoloids. It also occurs in American Indians and in Europeans. Among the latter groups, however, the proportion of palatine tori is greater. This suggests a different mode of inheritance (*36*).

Sinanthropus and Modern Mongoloids

The time depth for contemporary Mongoloid types is short, perhaps on the order of 10,000 to 15,000 years. The record of changes within the last several hundred years is considerable. Therefore, the finding that Middle Pleistocene *Sinanthropus pekinensis* displays traits that recur in Mongoloid and related populations, such as American Indians and Polynesians, is of major importance.

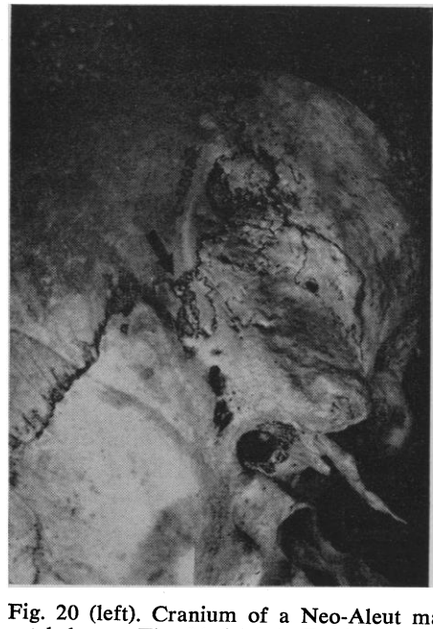
It has not been definitely established that any of the fossil men of China are Mongoloids. The most frequently mentioned as being so are three skulls from the Upper Cave of Chau Kou Tien, in north China. They are thought to be late Pleistocene, but they are probably no older than early American Indian remains such as the "Midland Woman," to which a date earlier than 8000 B.C., and possible as early as 18,500 B.C., has been assigned. These three skulls are quite different from each other and have been individually compared to skulls of Melanesians, Europeans, and Eskimos. The best appraisal that can be made is that they resemble "unmigrated American Indians" (*37*). Other fossil men of China do not look like Mongoloids of the last 5000 years. The evidence from China indicates that modern Mongoloids are a relatively recent development (*38*).

Japan offers no early materials that can be categorized as Mongoloid. The Pleistocene remains are fragmentary. Ushikawa Man has been assigned a date in the Upper Middle-Pleistocene, but the fossil consists only of a portion of the left humerus. The Mikkabi skull fragments are Upper Pleistocene, but no racial assignment is possible (*39*). The earliest definitely Mongoloid remains in Japan are from the last few thousand years.

Weidenreich observed that *Sinanthropus pekinensis* displayed 12 traits found in Mongoloids, in which category he included Polynesians and American Indians. Three of the 12 fit into the category of traits that may or may not occur in Mongoloids—the mandibular torus, shovel-shaped incisors, and the Inca bone (Figs. 18 and 19). Two other traits of the 12 are also relevant. Weidenreich noted that in all the temporal bones there was a well-marked notch (parietal incisure). This is common in modern Mongoloids, though it is not limited to them. In many of the fossils a separate bone is found at this site (Fig. 20); these separate bones can simply be considered examples of extremely well marked notches. There are slits in both tympanic plates of Skull III. These slits occur in the same area as the tympanic dehiscence of modern Mongoloids and are probably related to it (Fig. 21). The auditory exostoses described by Weidenreich occur most often in American Indians; they do not occur in Eskimos or Aleuts. When we review these traits in *Sinanthropus* and in modern Mongoloids, keeping their general morphology in mind, we cannot consider them grounds for regarding *Sinanthropus* as a Mongoloid. On the other hand, these traits are additional evidence of similarity between *Sinanthropus* and modern man, especially Mongoloids and American Indians. Further evaluation must wait for comparable data from the other representatives of the erectus stage in Java, Africa, and Europe. In discussing the nomenclature and classification of *Sinanthropus*, Weidenreich remarked (*40*): "It would be best to call it *'Homo sapiens erectus pekinensis'*. Otherwise it would appear as a proper 'species', different from *'Homo sapiens'* which remains doubtful, to say the least."

Recent Changes

There is good evidence from Japan, Alaska, and Greenland that appreciable changes in morphology have taken place within a relatively short period. Suzuki has documented differences between protohistoric times (the 4th to 8th centuries A.D.) and modern times (*41*). The ancient Japanese had long heads, broad faces, and wide, flat nasal



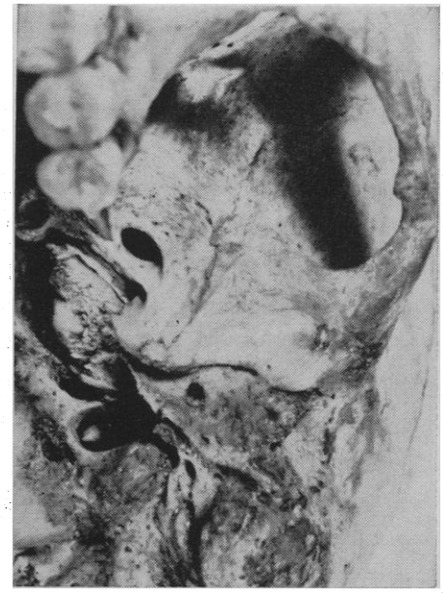


Fig. 20 (left). Cranium of a Neo-Aleut male from Chaluka, showing multiple parietal notch bones. Fig. 21 (right). Dehiscences and marginal foramen on the tympanic plate of a Paleo-Aleut. Both these features are related to the "infantile gap" in *Sinanthropus pekinensis*. The dehiscence or perforation is a feature that is often found in the tympanic bone of humans, most frequently in Mongoloids and related races.

roots, and they were prognathic. The later Japanese had rounder heads, narrower faces, and narrower and higher nasal roots, and they were less prognathic. The possibility that there was admixture with other races is slight. By the 7th century the Japanese people numbered 6 million; this density of population would, of itself, have been an effective barrier against the effects of mixture with immigrants.

The mean cranial index for Paleo-Aleut males is 74, and the mean cephalic index for Aleuts now living in the same area is 85. Subtracting 2 index units from the latter value (a step that is necessary in comparing cephalic indexes of the living with cranial indexes), we find a difference of 9 index units, representing a large change in the ratio of length to breadth. The cranial index for early male Koniags of Kodiak Island is 77, in marked contrast to the index of 86 for later Koniags. A similar but smaller change has taken place in east Greenland, where there can be no question of admixture (*19*). Similar changes, and also an increase in stature, are reported for many series of American Indians (*42*). Local migrations may explain the change in particular places but cannot explain the change for all the areas involved. The question of local evolutionary changes must be given more attention.

Summary

The emerging picture for the immediate origin of New World Mongoloids, the Eskimos and Aleuts, is that of a Bering platform inhabited by contiguous isolates stretching from Hokkaido around to what is now Umnak Island, probably some 10,000 to 15,000 years ago. The lithic similarities between Anangula and Hokkaido and the similarities in human morphology suggest this. The probable linguistic relationship between Eskimo and Aleut on the one hand and Chukchi, Koryak, and Kamchadal on the other is in general agreement with this picture and raises the possibility that the Yupik-speaking Eskimos of Siberia and St. Lawrence Island may be derived from populations that formerly lived on the Bering Platform and withdrew toward their present locations as the platform was inundated. Diffusion of traits, both genetic and cultural, from the center in southwestern Alaska became of increasing importance as the population differential between south and north became greater. Once Bering Strait became a channel, major migrations ended; successional continuity is indicated wherever deep stratified sites are found. Paleo-Indians (proto-Mongoloids or semi-Mongoloids) were clearly established in South and Central America before 10,000 B.C. Their separation from ancestral Eskimo-Aleut-Chukchi Mongoloids was probably insured by differences in economic adaptation and therefore by differences in their routes of migration into the New World. The land bridge that connected Siberia and Alaska during early Wisconsin time, as early as 35,000 years ago and as late as 11,000 years ago, was more than 1000 miles wide. The ancestral Indians, with their land-based economy, could have crossed often, following big game, without coming in contact with the Mongoloids, who worked their way along the coastal edge of the reduced Bering Sea.

Upon reaching the end of the Bering Platform, the Umnak Island of today, the Mongoloids flourished, owing to the richness of the marine fauna. As deglaciation proceeded from west to east, they spread in two directions, following the retreating ice and setting out in boats toward the western Aleutian Islands. The earliest known Aleut skeleton is some 4000 years old. Early Kodiak Eskimo skeletons slightly less old are easily distinguishable from the Aleut skeleton. The populations have not become demonstrably more similar, but they have undergone some parallel changes.

As a distinctive group in their present form, Mongoloids represent a recent evolutionary development that has occurred within the past 15,000 years. They do share more discontinuous traits with middle-Pleistocene *Sinanthropus* than members of any other living racial divisions, though *Sinanthropus* is clearly different from a modern Mongoloid. Inferences concerning long-term connections must remain tentative in view of the small number of fossil remains, the great time spans, and the deficiencies in our knowledge of the modes of inheritance of many traits. However, when we find that significant differences have developed, over a short time span, between closely related and contiguous peoples, as in Alaska and Greenland, and when we consider the vast differences that exist between remote groups such as Eskimos and Bushmen, who are known to belong within the single species of *Homo sapiens*, it seems justifiable to conclude that *Sinanthropus* belongs within this same diverse species.

References and Notes

1. E. Sapir, *Can. Dept. Mines Geol. Surv. Mem. 90, Anthropol. Ser.* **13(1916)**, 76 (1916).
2. G. Marsh and M. Swadesh, *Intern. J. Am. Linguistics* **17**, 209 (1951).
3. M. Swadesh, in *Proc. Intern. Congr. Americanists, 32nd, Copenhagen* (1958), pp. 671–674.
4. ———, *Am. Anthropologist* **64**, 1262 (1962).
5. L. L. Hammerich, in *Proc. Intern. Congr. Americanists, 32nd, Copenhagen* (1958), pp. 640–644; C. F. Voegelin, *Univ. Ariz. Bull.* **29**, 47 (1958).
6. A. L. Kroeber, *Univ. Calif. (Berkeley) Publ. Am. Archaeol. Ethnol. No. 38* (1939).
7. W. S. Laughlin, *Anthropol. Papers Univ. Alaska* **1**, 25 (1952); *ibid.* **6**, 5 (1957).
8. ——— and G. H. Marsh, *Am. Antiquity* **20**, 27 (1954).
9. ———, *Anthropol. Papers Univ. Alaska* **5**, 5 (1956).
10. J. L. Giddings, *Current Anthropol.* **1**, 121 (1960).
11. W. N. Irving, *Arctic Institute of North America Technical Paper 11* (1962), pp. 55–68.
12. H. B. Collins, *ibid.*, pp. 126–139.
13. W. S. Laughlin and W. G. Reeder, *Science* **137**, 856 (1962).
14. V. B. Scheffer, *Seals, Sea Lions, and Walruses* (Stanford Univ. Press, Stanford, Calif., 1958).
15. A. Hrdlicka, *The Aleutian and Commander Islands* (Wistar Institute, Philadelphia, 1945).
16. W. S. Laughlin and G. H. Marsh, *Arctic* **4**, 74 (1951).
17. C. F. A. Moorrees, *The Aleut Dentition* (Harvard Univ. Press, Cambridge, Mass., 1957); A. A. Dahlberg, *Arctic Anthropol.* **1**, 115 (1962).
18. W. S. Laughlin, in *The Physical Anthropology of the American Indian*, W. S. Laughlin, Ed. (Viking Fund, New York, 1951).
19. ———, in *Proc. Intern. Congr. Americanists, 32nd, Copenhagen* (1958), pp. 516–530.
20. A. Hrdlicka, *The Anthropology of Kodiak Island* (Wistar Institute, Philadelphia, 1944).
21. W. E. Taylor, *Anthropologica* **1**, 24 (1959).
22. W. S. Laughlin and W. E. Taylor, *National Museum of Canada Bull. 167* (1960), pp. 1–28.
23. F. A. Milan, thesis, University of Wisconsin (1963); L. K. Miller and L. Irving, *J. Appl. Physiol.* **17**, 449 (1962); B. G. Covino, *Federation Proc.* **20**, 209 (1961); K. Rodahl and D. Rennie, *Arctic Aeromedical Laboratory Technical Rept. 8-7951* (1957); G. M. Brown and J. Page, *J. Appl. Physiol.* **5**, 221 (1952); G. M. Brown, J. D. Hatcher, J. Page, *ibid.* **5**, 410 (1953); J. P. Meehan, A. Stoll, J. D. Hardy, *ibid.* **6**, 397 (1954).
24. I. Veniaminov, *Notes on the Islands of the Unalaska Division* (St. Petersburg, 1840).
25. G. H. Marsh and W. S. Laughlin, *Southwestern J. Anthropol.* **12**, 38 (1956); W. S. Laughlin, in "Man's Image in Medicine and Anthropology," I. Galdstone, Ed. (in press).
26. C. F. Merbs and W. H. Wilson, *National Museum of Canada Bull. 180* (1962), pp. 154–180; T. D. Stewart, *J. Bone Joint Surg.* **35A**, 937 (1953); ———, *Clin. Orthopaed.* **8**, 44 (1956).
27. M. G. Levin, *Sov. Ethnografiya* **1958**, No. 5, 8 (1958) (in Russian); ———, *ibid.* **1959**, No. 3, 98 (1959) (in Russian); W. C. Boyd, *Science* **140**, 1057 (1963).
28. B. Chown and M. Lewis, *National Museum of Canada Bull. 167* (1960), pp. 66–79.
29. ———, *Am. J. Phys. Anthropol.* **17**, 13 (1959).
30. W. S. Laughlin, *Cold Spring Harbor Symp. Quant. Biol.* **15(1950)**, 165 (1950); A. E. Mourant, *The Distribution of the Human Blood Groups* (Blackwell, Oxford, 1954).
31. A. C. Allison, B. S. Blumberg, S. M. Gartler, *Nature* **183**, 118 (1959); B. S. Blumberg, A. C. Allison, B. Garry, *Ann. Human Genet.* **23**, 349 (1959).

32. R. Gessain, *Medd. Grønland* **161**, No. 4 (1960).
33. J. B. Jørgensen and W. S. Laughlin, *Folk* **5**, 199 (1963).
34. W. S. Laughlin and J. B. Jørgensen, *Acta Genet. Statist. Med.* **6**, 3 (1956).
35. F. Boas, *Science* **30**, 535 (1909).
36. C. F. A. Moorrees, R. H. Osborne, E. Wilde, *Am. J. Phys. Anthropol.* **10**, 319 (1952).
37. W. Howells, *Mankind in the Making* (Doubleday, New York, 1959), p. 300.
38. K. Chang, *Science* **136**, 749 (1962).
39. H. Suzuki, in *Actes du 6e Congrès International des Sciences Anthropologiques et Ethnologiques* (Paris, 1960), vol. 1; *Zinruigaku Zassi* **70**, 1 (1962).
40. F. Weidenreich, *Palaeontol. Sinica* **1943**, No. 10, 127, 246, 256 (1943).
41. H. Suzuki, in *Selected Papers of the Fifth International Congress of Anthropology and Ethnological Sciences* (Philadelphia, 1956), pp. 717–724.
42. M. T. Newman, *Am. Anthropologist* **64**, 237 (1963).
43. Professor Penrose adjusted his coefficient of divergence to accommodate discrete traits, made the original three-dimensional model, and provided a photograph from which the figure was drawn.

R&D, and the Relations of Science and Government

A statement before a congressional subcommittee by the retiring president of the AAAS.

Paul M. Gross

Mr. Daddario and members of the Subcommittee, I appreciate the opportunity to meet with you today to discuss some of the persistent problems involved in the relations between government and science. I will touch on only a few major areas, for it seems to me that this Subcommittee has a special opportunity to consider the underlying and more fundamental issues.

When you invited the American Association for the Advancement of Science to take part in these hearings, you asked us to consider two questions: (i) What are some of the most important or difficult problems involved in the relations between government and science? and (ii) How might the Association be of help in enabling the Congress to deal more effectively with issues in which science and government interact?

In taking up the first of these two questions, I should like to try to get behind the specifics of particular fields of research and particular aspects of their administrative management to consider some of the basic, persistent problems of government-science relationships. Because these problems are fundamental and persistent, they deserve the thoughtful consideration of the Subcommittee, of the Congress, and of the scientific community.

I start with the premise that the present character and size of federal research and development expenditures owe their initiation in large measure to ideas and concepts originating in the scientific community. The basic research supported by the National Institutes of Health, the National Science Foundation, and other agencies is almost wholly determined by the scientists themselves, who decide what seems worth working on. The applied research and developmental programs of the Department of Defense, the Atomic Energy Commission, NASA, NIH, and other agencies have become possible as a result of work which, in the main, was initiated by scientists. As some of that work developed, it became clear that it could and should be exploited to serve military, industrial, health, and prestige goals of the nation.

In appropriating funds for research and development, the Congress has certain objectives in mind, as have the executive agencies in submitting their R&D budgets. In submitting proposals for work that is to be funded from these appropriations, scientists and engineers on the staffs of university, industrial, and other research laboratories also have certain objectives in mind. In the long run and in general, there is agreement between the objectives of the government and those of the scientists and engineers, but the match is not always a perfect one, and the amount of agreement may be greater in the long run than in the short run, and greater for some kinds of research activities than for others.

Both scientists and government officials understand, however, that there is a strong interdependence between the government, which depends upon industrial and educational research laboratories to conduct research, and those laboratories, which depend upon the government for a large fraction of the necessary financial support. Because of this interdependence, there is need for mutual understanding, and sometimes for compromise and adjustment. There is also need for the kind of analysis of basic problems that this Subcommittee is undertaking.

A Four-Part Subject

Some of the problems could be clarified if we think of the whole subject as having four main parts:

1) *Applied research.* I place this first because much the largest fraction of the total R&D budget is spent for the development, the testing, and the associated applied research involved in perfecting or bringing into use new equipment, new methods, and new products. A great deal of money is required to develop—for example—a new weapon system, but the objective can be foreseen with reasonable clarity, and it is thus reasonably easy to make some of the necessary decisions. Nevertheless, it is rare that such a system can be perfected without our first finding gaps in our fundamental scientific knowledge. Thus we do not go very far in a broad consideration of applied research before we find ourselves thinking about the second

On 22 October 1963 Dr. Gross appeared, at its request, before the Subcommittee on Science, Research, and Development of the Committee on Science and Astronautics of the House of Representatives. His statement is here slightly edited.