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Microenvironments and Mesoamerican Prehistory

Fine-scale ecological analysis clarifies the transition to settled life in pre-Columbian times.

Michael D. Coe and Kent V. Flannery

A crucial period in the story of the pre-Columbian cultures of the New World is the transition from a hunting-and-collecting way of life to effective village farming. We are now fairly certain that Mesoamerica (*1*) is the area in which this took place, and that the time span involved is from approximately 6500 to 1000 B.C., a period during which a kind of "incipient cultivation" based on a few domesticated plants, mainly maize, gradually supplemented and eventually replaced wild foods (*2*). Beginning probably about 1500 B.C., and definitely by 1000 B.C., villages with all of the signs of the settled arts, such as pottery and loom-weaving, appear throughout Mesoamerica, and the foundations of pre-Columbian civilization may be said to have been established.

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Much has been written about food-producing "revolutions" in both hemispheres. There is now good evidence both in the Near East and in Mesoamerica that food production was part of a relatively slow *evolution*, but there still remain several problems related to the process of settling down. For the New World, there are three questions which we would like to answer.

1) What factors favored the early development of food production in Mesoamerica as compared with other regions of this hemisphere?

2) What was the mode of life of the earlier hunting-and-collecting peoples in Mesoamerica, and in exactly what ways was it changed by the addition of cultivated plants?

3) When, where, and how did food production make it possible for the first truly sedentary villages to be established in Mesoamerica?

The first of these questions cannot be answered until botanists determine the habits and preferred habitats of the wild ancestors of maize, beans, and the various cucurbits which were domesticated. To answer the other questions, we must reconstruct the human-ecological situations which prevailed.

Some remarkably sophisticated, multidisciplinary projects have been and still are being carried out elsewhere in the world, aimed at reconstructing prehistoric human ecology. However, for the most part they have been concerned with the adaptations of past human communities to large-scale changes in the environment over very long periods—that is, to alterations in the *macroenvironment*, generally caused by climatic fluctuations. Such alterations include the shift from tundra to boreal conditions in northern Europe. Nevertheless, there has been a growing suspicion among prehistorians that macroenvironmental changes are insufficient as an explanation of the possible causes of food production and its effects (*3*), regardless of what has been written to the contrary.

Ethnography and Microenvironments

We have been impressed, in reading anthropologists' accounts of simple societies, with the fact that human communities, while in some senses limited by the macroenvironment—for instance, by deserts or by tropical forests (*4*)—usually exploit several or even a whole series of well-defined *microenvironments* in their quest for food (*5*). These microenvironments might be defined as smaller subdivisions of large ecological zones; examples are the immediate surroundings of the ancient archeological site itself, the bank of a nearby stream, or a distant patch of forest.

An interesting case is provided by the Shoshonean bands which, until the mid-19th century, occupied territories within the Great Basin of the American West (*6*). These extremely primitive peoples had a mode of life quite similar to that of the peoples of Mesoamerica of the 5th millennium B.C., who were the first to domesticate maize. The broadly limiting effects of the Great Basin (which, generally speaking, is a desert) and the lack of knowledge of irrigation precluded any effective form of agriculture, even though some bands actually sowed wild grasses and one group tried an ineffective watering of wild crops. Consequently, the Great Basin aborigines remained on a hunting and plant-collecting level, with extremely low population densities and a very simple social organization. However, Steward's study (*6*) shows that each band was not inhabiting a mere desert but moved on a strictly followed seasonal round among a vertically and horizontally differentiated set of microenvironments, from the lowest salt flats up to piñon forest, which were "niches" in a human-ecological sense.

The Great Basin environment supplied the potential for cultural development or lack of it, but the men who lived there selected this or that microenvironment. Steward clearly shows that *how* and *to what* they adapted influenced many other aspects of their culture, from their technology to their settlement pattern, which was necessarily one of restricted wandering from one seasonally occupied camp to another.

Seasonal wandering would appear to be about the only possible response of a people without animal or plant husbandry to the problem of getting enough food throughout the year. Even the relatively rich salmon-fishing cultures of the Northwest Coast (British Columbia and southern Alaska) were without permanently occupied villages. Contrariwise, it has seemed to us that only a drastic reduction of the number of niches to be exploited, and a concentration of these in space, would have permitted the establishment of full-time village life. The ethnographic data suggest that an analysis of microenvironments or niches would throw much light on the processes by which the Mesoamerican peoples settled down.

Methodology

If the environment in which an ancient people lived was radically different from any known today, and especially if it included animal and plant species which are now extinct and whose behavior is consequently unknown, then any reconstruction of the subsistence activities of the people is going to be difficult. All one could hope for would be a more-or-less sound reconstruction of general ecological conditions, while a breakdown of the environment into smaller ecological niches would be impossible. However, much if not most archeological research concerns periods so recent in comparison with the million or so years of human prehistory that in most instances local conditions have not changed greatly in the interval between the periods investigated and the present.

If we assume that there is a continuity between the ancient and the modern macroenvironment in the area of interest, there are three steps which we must take in tracing the role of microenvironments.

1) Analysis of the present-day microecology (from the human point of view) of the archeological zone. Archeological research is often carried out in remote and little known parts of the earth, which have not been studied from the point of view of natural history. Hence, the active participation of botanists, zoologists, and other natural scientists is highly recommended.

The modern ethnology of the region should never be neglected, for all kinds of highly relevant data on the use of surrounding niches by local people often lie immediately at hand. We have found in Mesoamerica that the workmen on the "dig" are a mine of such information. There may be little need to thumb through weighty reports on the Australian aborigines or South African Bushmen when the analogous custom can be found right under one's nose (*7*). The end result of the analysis should be a map of the microenvironments defined (here aerial photographs are of great use), with detailed data on the seasonal possibilities each offers human communities on certain technological levels of development.

2) Quantitative analysis of food remains in the archeological sites, and of the technical equipment (arrow or spear points, grinding stones for seeds, baskets and other containers, and so on) related to food-getting. It is a rare site report that treats of bones and plant remains in any but the most perfunctory way. It might seem a simple thing to ship animal bones from a site to a specialist for identification, but most archeologists know that many zoologists consider identification of recent faunal remains a waste of time (*8*). Because of this, and because many museum collections do not include postcranial skeletons that could be used for identification, the archeologist must arrange to secure his own comparative collection. If this collection is assembled by a zoologist on the project, a by-product of the investigation would be a faunal study of microenvironments. Similarly, identification of floral and other specimens from the site would lead to other specialized studies.

3) Correlation of the archeological with the microenvironmental study in an overall analysis of the ancient human ecology.

The Tehuacán Valley

An archeological project undertaken by R. S. MacNeish, with such a strategy in mind, has been located since 1961 in the dry Tehuacán Valley of southern Puebla, Mexico (*2*, *9*). The valley is fringed with bone-dry caves in which the food remains of early peoples have been preserved to a remarkable degree in stratified deposits. For a number of reasons, including the results of his past archeological work in Mesoamerica, MacNeish believed that he would find here the origins of maize agriculture in the New World, and he has been proved right. It now seems certain that the wild ancestor of maize was domesticated in the Tehuacán area some time around the beginning of the 5th millennium B.C.

While the Tehuacán environment is in general a desert, the natural scientists of the project have defined within it four microenvironments (Fig. 1).

1) *Alluvial valley floor*, a level plain sparsely covered with mesquite, grasses, and cacti, offering fairly good possibilities, especially along the Río Salado, for primitive maize agriculture dependent on rainfall.

2) *Travertine slopes*, on the west side of the valley. This would have been a niche useful for growing maize

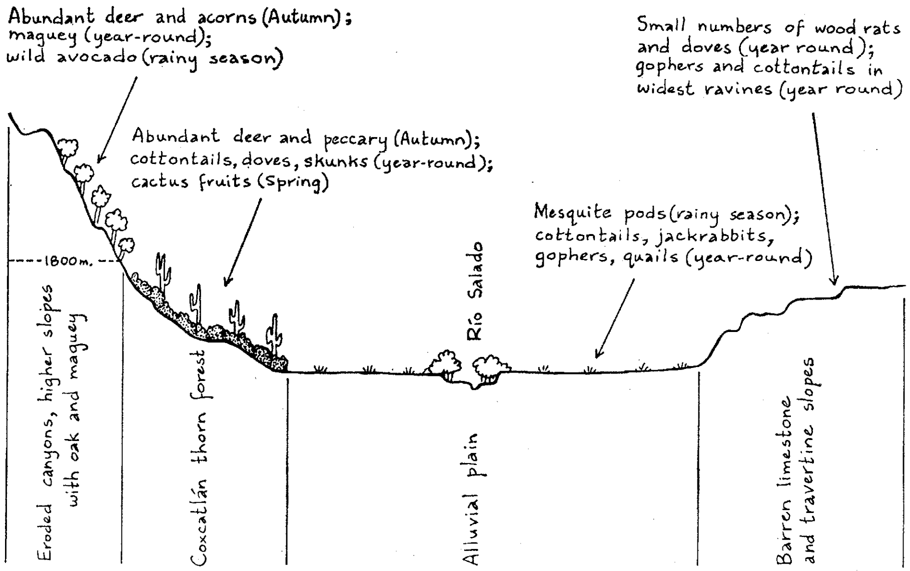

Fig. 1. An idealized east-west transection of the central part of the Tehuacán Valley, Puebla, Mexico, showing microenvironments and the seasons in which the food resources are exploited. East is to the left. The length of the area represented is about 20 kilometers.

and tomatoes and for trapping cottontail rabits.

3) *Coxcatlán thorn forest*, with abundant seasonal crops of wild fruits, such as various species of *Opuntia*, pitahaya, and so on. There is also a seasonal abundance of whitetail deer, cottontail rabbits, and skunks, and there are some peccaries.

4) *Eroded canyons*, unsuitable for exploitation except for limited hunting of deer and as routes up to maguey fields for those peoples who chewed the leaves of that plant.

The correlation of this study with the analysis, by specialists, of the plant and animal remains (these include bones, maize cobs, chewed quids, and even feces) found in cave deposits has shown that the way of life of the New World's first farmers was not very different from that of the Great Basin aborigines in the 19th century. Even the earliest inhabitants of the valley, prior to 6500 B.C., were more collectors of seasonally gathered wild plant foods than they were "big game hunters," and they traveled in microbands in an annual, wet-season-dry-season cycle (*10*). While slightly more sedentary macrobands appeared with the adoption of simple maize cultivation after 5000 B.C., these people nevertheless still followed the old pattern of moving from microenvironment to microenvironment, separating into microbands during the dry season.

The invention and gradual improvement of agriculture seem to have made few profound alterations in the settlement pattern of the valley for many millennia. Significantly, by the Formative period (from about 1500 B.C. to A.D. 200), when agriculture based on a hybridized maize was far more important than it had been in earlier periods as a source of food energy, the pattern was still one of part-time nomadism (*11*). In this part of the dry Mexican highlands, until the Classic period (about A.D. 200 to 900), when irrigation appears to have been introduced into Tehuacán, food production had still to be supplemented with extensive plant collecting and hunting.

Most of the peoples of the Formative period apparently lived in large villages on the alluvial valley floor during the wet season, from May through October of each year, for planting had to be done in May and June, and harvesting, in September and October. In the dry season, from November through February, when the trees and bushes had lost their leaves and the deer were easy to see and track, some of the population must have moved to hunting camps, principally in the Coxcatlán thorn forest. By February, hunting had become less rewarding as the now-wary deer moved as far as possible from human habitation; however, in April and May the thorn forest was still ripe for exploitation, as many kinds of wild fruit matured. In May it was again time to return to the villages on the valley floor for spring planting.

Now, in some other regions of Mesoamerica there were already, during the Formative period, fully sedentary village cultures in existence. It is clear that while the Tehuacán valley was the locus of the first domestication of maize, the origins of full-blown village life lie elsewhere. Because of the constraining effects of the macroenvironment, the Tehuacán people were exploiting, until relatively late in Mesoamerican prehistory, as widely spaced and as large a number of microenvironments as the Great Basin aborigines were exploiting in the 19th century.

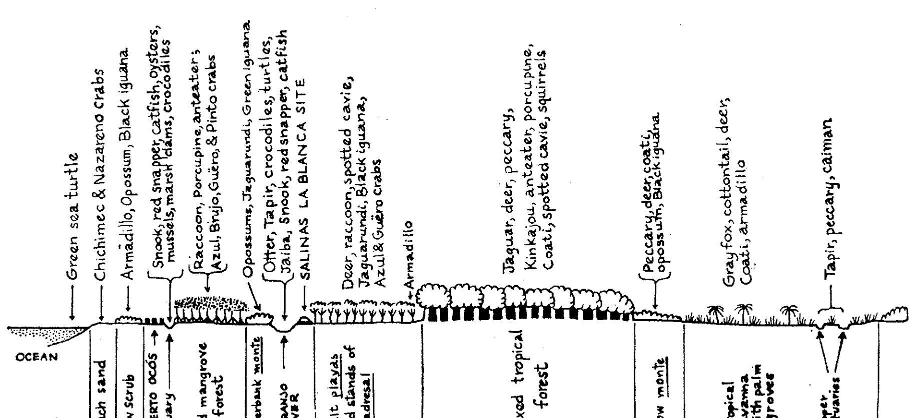

Fig. 2. Northeast-southwest transection of the Ocós area of coastal Guatemala, showing microenvironments in relation to the site of Salinas La Blanca. Northeast is to the right. The length of the area represented is about 15 kilometers.

Coastal Guatemala

Near the modern fishing port of Ocós, only a few kilometers from the Mexican border on the alluvial plain of the Pacific coast of Guatemala, we have found evidence for some of the oldest permanently occupied villages in Mesoamerica (*12*). We have also made an extensive study of the ecology and ethnology of the Ocós area.

From this study (*13*) we have defined no less than eight distinct microenvironments (Fig. 2) within an area of only about 90 square kilometers. These are as follows:

1) *Beach sand and low scrub*. A narrow, infertile strip from which the present-day villagers collect occasional mollusks, a beach crab called *chichimeco* and one known as *nazareño*, and the sea turtle and its eggs.

2) *The marine estuary-and-lagoon system*, in places extending considerably inland and ultimately connecting with streams or rivers coming down from the Sierra Madre. The estuaries, with their mangrove-lined banks, make up the microenvironment richest in wild foods in the entire area. The brackish waters abound in catfish (*Arius* sp. and *Galeichthys* sp.), red snapper (*Lutjanus colorado*), several species of snook (*Centropomus* sp.), and many other kinds of fish. Within living memory, crocodiles (*Crocodylus astutus*) were common, but they have by now been hunted almost to extinction. The muddy banks of the estuaries are the habitat of many kinds of mollusks, including marsh clams (*Polymesoda radiata*), mussels (*Mytella falcata*), and oysters (*Ostrea columbiensis*), and they also support an extensive population of fiddler and mud crabs.

3) *Mangrove forest*, consisting mainly of stilt-rooted red mangrove, which slowly gives way to white mangrove as one moves away from the estuary. We noted high populations of collared anteater (*Tamandua tetradactyla*) and arboreal porcupine (*Coendu mexicanus*). A large number of crabs (we did not determine the species) inhabit this microenvironment; these include, especially, one known locally as the *azul* (blue) crab, on which a large population of raccoons feeds.

4) *Riverine*, comprising the channels and banks of the sluggish Suchiate and Naranjo rivers, which connect with the lagoon-estuary system not far from their mouths. Freshwater turtles, catfish, snook, red snapper, and mojarra (*Cichlasoma* sp.) are found in these waters; the most common animal along the banks is the green iguana (*Iguana iguana*).

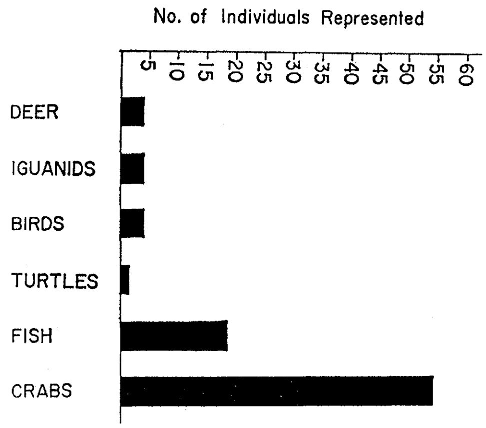

Fig. 3. Animal remains, exclusive of mollusks, found in Cuadros phase levels at Salinas La Blanca.

5) *Salt playas*, the dried remnants of ancient lagoon-and-estuary systems which are still subject to inundation during the wet season, with localized stands of a tree known as *madresal* ("mother of salt"). Here there is an abundance of game, including white-tail deer and the black iguana (*Ctenosaura similis*), as well as a rich supply of salt.

6) *Mixed tropical forest*, found a few kilometers inland, in slightly higher and better drained situations than the salt *playas*. This forest includes mostly tropical evergreens like the ceiba, as well as various zapote and fan palms, on the fruit of which a great variety of mammals thrive—the kinkajou, the spotted cavy, the coatimundi, the raccoon, and even the gray fox. The soils here are highly suitable for maize agriculture.

7) *Tropical savannah*, occupying poorly drained patches along the upper stream and estuary systems of the area. This is the major habitat in the area for cottontail rabbits and gray foxes. Other common mammals are the coatimundi and armadillo.

8) *Cleared fields and second growth*, habitats which have been created by agriculturists, and which are generally confined to areas that were formerly mixed tropical forest.

Among the earliest Formative cultures known thus far for the Ocós area is the Cuadros phase, dated by radiocarbon analysis at about 1000 to 850 B.C. and well represented in the site of Salinas La Blanca, which we excavated in 1962 (*14*). The site is on the banks of the Naranjo River among a variety of microenvironments; it consists of two flattish mounds built up from deeply stratified refuse layers representing house foundations of a succession of hamlets or small villages.

From our analysis of this refuse we have a good idea of the way in which the Cuadros people lived. Much of the refuse consists of potsherds from large, neckless jars, but very few of the clay figurines that abound in other Formative cultures of Mesoamerica were found. We discovered many plant remains; luckily these had been preserved or "fossilized" through replacement of the tissues by carbonates. From these we know that the people grew and ate a nonhybridized maize considerably more advanced than the maize which was then being grown in Tehuacán (*15*). The many impressions of leaves in clay floors in the site will, we hope, eventually make it possible to reconstruct the flora that immediately surrounded the village.

The identification of animal remains (Fig. 3), together with our ecological study and with the knowledge that the people had a well-developed maize agriculture, gives a great deal of information on the subsistence activities of these early coastal villagers. First of all, we believe they had no interest whatever in hunting, a conclusion reinforced by our failure to find a single projectile point in the site. The few deer bones that have been recovered are all from immature individuals that could have been encountered by chance and clubbed to death. Most of the other remains are of animals that could have been collected in the environs of the village, specifically in the lagoon-estuary system and the flanking mangrove forest, where the people fished, dug for marsh clams, and, above all, caught crabs (primarily the *azul* crab, which is trapped at night). Entirely missing are many edible species found in other microenvironments, such as raccoon, cottontail rabbit, peccary, spotted cavy, and nine-banded armadillo.

There is no evidence at all that occupation of Salinas La Blanca was seasonal. An effective food production carried out on the rich, deep soils of the mixed tropical forest zone, together with the food resources of the lagoon-estuary system, made a permanently settled life possible. Looked at another way, developed maize agriculture had so reduced the number and spacing of the niches which had to be exploited that villages could be occupied the year round (*16*).

Conditions similar to those of the Ocós area are found all along the Pacific Coast of Guatemala and along the

Gulf Coast of southern Veracruz and Tabasco in Mexico, and we suggest that the real transition to village life took place there and not in the dry Mexican highlands, where maize was domesticated initially (*17*).

Conclusion

The interpretation of archeological remains through a fine-scale analysis of small ecological zones throws new light on the move toward sedentary life in Mesoamerican prehistory. In our terms, the basic difference between peoples who subsist on wild foods and those who dwell in permanent villages is that the former must exploit a wide variety of small ecological niches in a seasonal pattern—niches which are usually scattered over a wide range of territory—while the latter may, because of an effective food production, concentrate on one or on only a few microenvironments which lie relatively close at hand.

Fine-scale ecological analysis indicates that there never was any such thing as an "agricultural revolution" in Mesoamerica, suddenly and almost miraculously resulting in village life. The gradual addition of domesticates such as maize, beans, and squash to the diet of wild plant and animal foods hardly changed the way of life of the Tehuacán people for many thousands of years, owing to a general paucity of the environment, and seasonal nomadism persisted until the introduction of irrigation. It probably was not until maize was taken to the alluvial, lowland littoral of Mesoamerica, perhaps around 1500 B.C., that permanently occupied villages became possible, through reduction of the number of microenvironments to which men had to adapt themselves.

References and Notes

1. Mesoamerica is the name given to that part of Mexico and Central America which was civilized in pre-Columbian times. For an excellent summary of its prehistory, see G. R. Willey, *Science* **131**, 73 (1960).
2. R. S. MacNeish, *Science* **143**, 531 (1964).
3. See C. A. Reed and R. J. Braidwood, "Toward the reconstruction of the environmental sequence of Northeastern Iraq," in R. J. Braidwood and B. Howe, "Prehistoric Investigations in Iraqi Kurdistan," *Oriental Institute, University of Chicago, Studies in Ancient Oriental Civilization No. 31* (1960), p. 163. Reed and Braidwood also convincingly reject the technological-deterministic approach of V. G. Childe and his followers.
4. See B. J. Meggers, *Am. Anthropologist* **56**, 801 (1954), for an environmental-deterministic view of the constraining effects of tropical forests on human cultures.
5. See F. Barth, *ibid.* **58**, 1079 (1956), for a microenvironmental approach by an ethnologist to the exceedingly complex interrelationships between sedentary agriculturists, agriculturists practicing transhumant herding, and nomadic herders in the state of Swat, Pakistan.
6. J. H. Steward, "Basin-Plateau Aboriginal Sociopolitical Groups," *Smithsonian Inst. Bur. Am. Ethnol. Bull. 120* (1938).
7. The pitfalls of searching for ethnological data relevant to archeological problems among cultures far-flung in time and space are stressed by J. G. D. Clark, *Prehistoric Europe, The Economic Basis* (Philosophical Library, New York, 1952), p. 3.
8. See W. W. Taylor, Ed., "The identification of non-artifactual archaeological materials," *Natl. Acad. Sci.–Natl. Res. Council Publ. 565* (1957). For a general article on the analysis of food remains in archeological deposits see R. F. Heizer in "Application of quantitative methods in archaeology," *Viking Fund Publications in Anthropology No. 28* (1960), pp. 93–157.
9. P. C. Mangelsdorf, R. S. MacNeish, W. C. Gallinat, *Science* **143**, 538 (1964). We thank Dr. MacNeish for permission to use unpublished data of the Tehuacán Archaeological-Botanical Project in this article.
10. R. S. MacNeish, *Second Annual Report of the Tehuacán Archaeological-Botanical Project* (Robert S. Peabody Foundation for Archaeology, Andover, Mass., 1962).
11. The research discussed in this and the following paragraph was carried out by Flannery as staff zoologist for the Tehuacán project during the field seasons of 1962 and 1963; see K. V. Flannery, "Vertebrate Fauna and Prehistoric Hunting Patterns in the Tehuacán Valley" (Robert S. Peabody Foundation for Archaeology, Andover, Mass., in press); ———, thesis, Univ. of Chicago, in preparation.
12. M. D. Coe, "La Victoria, an early site on the Pacific Coast of Guatemala," *Peabody Museum, Harvard, Papers No. 53* (1961).
13. The study was carried out largely by Flannery.
14. The final report on Salinas La Blanca by Coe and Flannery is in preparation. The research was supported by the National Science Foundation under a grant to the Institute of Andean Research, as part of the program "Interrelationships of New World Cultures." The oldest culture in the area is the Ocós phase, which has complex ceramics and figurines; the paleoecology of Ocós is less well known than that of Cuadros, which directly follows it in time.
15. P. C. Mangelsdorf, who has very kindly examined these maize specimens, informs us that they are uncontaminated with *Tripsacum*, and that probably all belong to the primitive lowland race, Nal-Tel.
16. To paraphrase the concept of "primary forest efficiency," developed by J. R. Caldwell ["Trend and Tradition in the Eastern United States," *Am. Anthropol. Assoc. Mem. No. 88* (1958)], we might think of the Cuadros phase as leaning to a "primary lagoon-estuary efficiency." We might think the same of the Ocós phase of the same region, which may date back to 1500 B.C.
17. An additional factor which may in part account for the priority of coastal Guatemala over Tehuacán in the achievement of a sedentary mode of life is the presence of an extensive system of waterways in the former region, which might have made it less necessary for local communities to move to productive sources of food. By means of canoes, a few persons could have brought the products of other niches to the village. However, our evidence indicates that the Cuadros people largely ignored the possibilities of exploiting distant niches.

Thermal Control in Space Vehicles

Organic coatings provide convenient and relatively inexpensive means of regulating interior temperature.

A. L. Alexander

Since the initial space probes and satellites were designed, the control of temperatures likely to accrue within the vehicles themselves has received increasing attention. As designs become more sophisticated, requirements for reliable thermal control have increased. In an early review of methods for controlling temperatures in satellites and space vehicles, Camack and Edwards (*1*) outlined quite precisely the necessity for temperature control. Temperatures of satellites and spacecraft must be controlled reliably to satisfy requirements of internal instruments and payloads—especially man. For example, electrical components have highly restrictive temperature limitations and, to a considerable degree, dictate the thermal design of the vehicle. Transistor networks are useful only btweeen 0° and about 60°C. Some batteries will operate efficiently only within quite narrow temperature limits, and nearly all biological processes must be maintained within a range of about 40°C. The conversion efficiency of silicon solar cells, used at present for photovoltaic conversion of solar to electrical energy, increases markedly as tempera-