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# Residential Patterns at Monte Alban, Oaxaca, Mexico

## Household remains excavated at a prehistoric urban center document the emergence of class structure.

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Monte Alban, situated atop a mountain mass in the center of the Valley of Oaxaca, Mexico, is the largest archeological site of the Classic period in the southern Mesoamerican highlands, and is the ancient center of the Zapotec Empire. Like other sites that date back to the Classic period, such as Teotihuacan to the northwest and Kaminaljuyu to the southeast, Monte Alban contains the archeological record of the founding, growth, development, and decline of a major urban center. At the peak of its development Monte Alban may have had several tens of thousands of inhabitants (*1*). The archeological record can, of course, be studied from many viewpoints ranging from art history and aesthetics to subsistence patterns and demography. From an anthropological perspective the rise and decline of prehistoric urban centers can be seen in terms of changing social relations and the emergence of new groups of people within the society. For this reason an approach designed to determine the nature and interaction of the groups that composed the society seems particularly appropriate for studying Monte Alban. One of the most accessible means to the study of social organization at Monte Alban is through data on household organization. Although previous excavations at the site yielded some information on households, it was not until completion of the 1972 to 1973 excavations in a residential area that certain patterns related to the colonization and growth of Monte Alban became clear (Fig. 1).

A distinction can be drawn between the household as an ethnographic reality and the household as manifested in the archeological record. An "ethnographic household" can be defined loosely as a group of people who cooperate in performing domestic activities such as obtaining, preparing, and consuming food; caring for the young and sick; and maintaining a house and other facilities that serve as the spatial focus for the group. Through the archeological record one can study households of a past ethnographic reality including such things as household composition, activities, the relation between household and family, and interaction between households.

I use the term "household cluster" for the archeological manifestation of past households at Monte Alban, because excavations there and elsewhere in the Valley of Oaxaca have shown that certain kinds of cultural features, or household cluster elements, are frequently found in spatial association. These include (i) evidence of house structures consisting of walls, floors, postholes, and adobe wall fragments; (ii) burials and tombs; (iii) large subsurface bell-shaped or cylindrical storage pits; (iv) hearths and ovens; and sometimes (v) miscellaneous features such as retaining walls, drains, and small pits (*2, 3*).

At least two advantages are gained by choosing the household as the unit of study and analysis. First, the household is universal in the sense that practically all members of any society belong to one, whereas most other social groups such as craft guilds, sodalities, or classes have relatively restricted membership. Second, archeological evidence of households is plentiful, easy to locate, and lends itself to direct interpretation, which is rarely the case with evidence of other social groups. I assume that households reflect and manifest the social, political, and economic situation in society, but the degree to which this is true and the specific form of the manifestation cannot be assumed in advance but must come out of the analysis.

The Monte Alban chronological sequence is divided into periods I through V, from early to late, with subdivisions Ia, Ib, Ic, transition period II–IIIA, and IIIB (*4*). In this article I deal mainly with periods I and IIIB, the endpoints of the Monte Alban occupation. The site was founded around 500 B.C. in period Ia which, at some other sites in the Valley of Oaxaca, is preceded by the Rosario phase (*5*). Period IIIB was the last major time of building before the abandonment of Monte Alban, although human remains were interred and some minor construction may have occurred in subsequent, Postclassic times. Recent work at the Valley of Oaxaca site of Lambityeco has yielded a series of radiocarbon dates for period IV which cluster around A.D. 700 (*6*). If 100 years are allowed for the development of distinctive period IV traits, the end of period IIIB can be placed at approximately A.D. 600, which would mean that Monte Alban was occupied for about 1100 years from approximately 500 B.C. to A.D. 600.

An area of slightly over 1500 square meters was exposed in the 1972 to 1973 excavations, on terraces designated 634, 635, and 636 in Blanton's surface survey (*1*). I estimate that no more than 1 percent of the total residential zone has been uncovered in all excavations at Monte Alban.

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## Colonization of Monte Alban

Information from the 1972 to 1973 excavations at Monte Alban, together with the discovery since 1966 of a long pre-Monte Alban cultural sequence at other Valley of Oaxaca sites, indicate that Monte Alban was probably colonized by households from the Valley of Oaxaca. This contrasts with an earlier interpretation that Monte Alban was founded by people from outside the valley (*7*, p. 95). Recent data from Monte Alban also support the interpretation that at least at one level of society there was continuity in household composition and activities and probably little disruption of the social order during the time of colonization of Monte Alban.

It is possible that people from other areas arrived at Monte Alban and either possessed or quickly adopted the kind of household organization present in the valley just before the colonization of Monte Alban. However, the idea that Monte Alban was colonized by inhabitants of the Valley of Oaxaca is a more parsimonious account and is more reasonable when one considers that the valley was extensively inhabited prior to period Ia. There is also evidence for population decrease at some valley sites just at the time when Monte Alban was founded. Since 1966, portions of several different village sites, each with several hundred years of occupation before period Ia, have been excavated in the Valley of Oaxaca (*8*). I have examined material from five of these sites and only two of them, Barrio del Rosario Huitzo and Santo Domingo Tomaltepec, have yielded what I consider to be primary deposits of Ia date. In the cases of two of the other sites, San Jose Mogote and San Sebastian Abasolo, this absence could be due to the relatively small areas excavated, and, in fact, surface collections indicate that San Jose Mogote probably had a large population during period Ia. The site of Tierras Largas, on the other hand, was sampled intensively and, although Ia sherds were found in mixed context, no primary deposits were recovered. Household clusters prior to period Ia are abundant at Tierras Largas, so the scarcity of Ia material there probably indicates population decrease. Tierras Largas is probably one of the sites from which the colonizers of Monte Alban originated.

Household clusters from periods Ia and Ib at Monte Alban show several similarities to pre-Monte Alban household clusters from Tierras Largas (*3*):

1) Spatial layout of the household cluster. A cluster consists of a house structure with some combination of pits, ovens, and human burials placed outside the structure but within a radius of less than about 10 meters. The house and permanent features occupy some 10 percent or less of the area of the cluster, and much of the space may have been used for temporary activities.

2) Spacing between household clusters. Most pre-Monte Alban clusters at Tierras Largas are spaced approximately 20 m apart. Early clusters at Monte Alban exhibit more or less the same spacing, although we excavated two period Ib clusters which are only 15 m apart but situated on different natural terraces.

3) House size and shape. The common type of pre-Monte Alban house is rectangular and measures approximately 3 by 5 or 4 by 6 m, which is similar to some period I houses excavated at Monte Alban in 1972 to 1973. However, the common pre-Monte Alban house is constructed of wattle and daub, while period I houses at Monte Alban have walls of adobe and caliche-like blocks placed on stone foundations.

4) Presence and size of storage pits. Guadalupe and Rosario phase storage pits excavated at Tierras Largas range in volume from 1.00 to 4.40 cubic meters with an average of 2.35. Period Ia and Ib bell-shaped pits excavated at Monte Alban range from 0.50 to 2.60 $m^3$ with an average of 1.70. The presence of pits at Monte Alban and pre-Monte Alban sites and the similarity in size may be more significant than the still unexplained variation in size.

5) Associated artifacts. Artifact analyses from the 1972 to 1973 excavations are incomplete, but my impression is that Ia deposits from Monte Alban contain the same kinds of items as have been found in pre-Monte Alban deposits at other sites. These include manos, metates, chert flakes, obsidian blades, ceramic figurines, shell ornaments, and a wide variety of ceramic vessel forms.

Household clusters at Tierras Largas are probably indicative of small

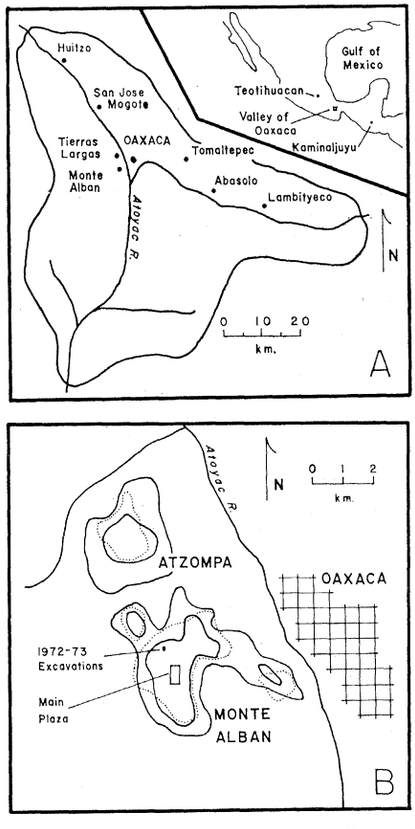


Fig. 1. (A) Location of the Valley of Oaxaca, the city of Oaxaca, and archeological sites mentioned in the text. (B) Monte Alban and the related site of Atzompa showing approximate extent of residential areas (dotted lines).

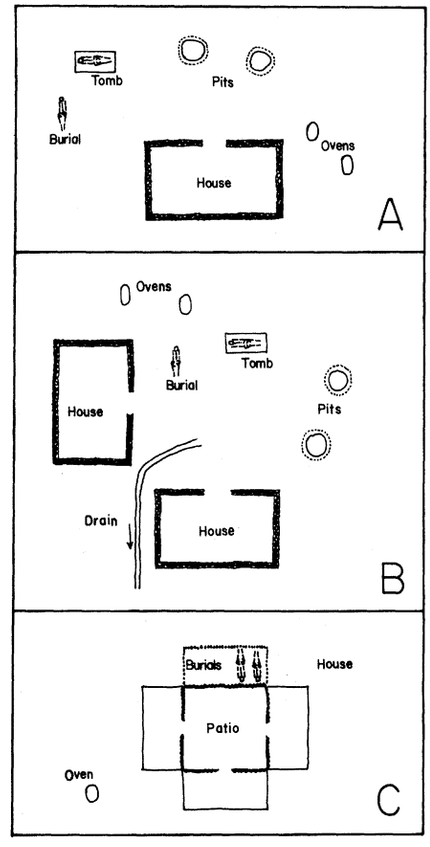


Fig. 2. Schematic representation of three kinds of household clusters found at Monte Alban. (A) Open household cluster; (B) semiclosed cluster; (C) closed household cluster.

nuclear families (*3*, pp. 164–168), and this may well be true of the Ia and Ib clusters at Monte Alban. The examples excavated there in 1972 to 1973 appear to be characteristic of the most common type of household in society at that time. To this extent the implication is that the founding of Monte Alban did not entail disruption of household organization. Households remained relatively autonomous and self-sufficient if one can judge from the presence of storage pits and evidence of a wide range of domestic activities associated with each household. It should be emphasized, however, that this evidence may reflect only one sector of period I society. Finer chronological control and a broad sample of period I household clusters is needed to provide a clearer picture of the beginning of Monte Alban.

### Open to Closed Household Cluster

Evidence recovered in the 1972 to 1973 excavations at Monte Alban indicates a change through time in spatial organization of household cluster elements. The trend from period Ia through IIIB is toward increased compactness of elements and a more formal definition of space. The development is probably a continuum but can be described in terms of three types (Fig. 2).

1) The open household cluster. This type occurs before the colonization of Monte Alban at sites like Tierras Largas and San Jose Mogote. It is found at Monte Alban from Ia into early period II times and consists of a rectangular house surrounded by an open area sometimes floored on the downslope side. Bell-shaped pits, ovens, burials—rarely tombs—and occasionally miscellaneous small features and drains occur on the flat area within about 10 m or less of the house. Perhaps most significant is the centrifugal outward orientation of the open household cluster with the house itself at the center and associated features scattered around it.

2) The closed household cluster. This type is typified by period IIIB houses consisting of rooms adjoining the sides of a square central patio with plaster floor. In small houses burials are frequently found in slab-lined graves beneath the floor of a room. Larger houses are walled compounds and often include a spacious tomb beneath the patio. In the examples excavated in 1972 to 1973, ovens were the only features found outside the rooms and patio. The closed household cluster with its central patio as focal point has a centripetal inward orientation which contrasts sharply with the open household cluster (*9*).

3) The semiclosed household cluster. This is intermediate both temporally and in compactness between the open and closed household cluster. In simplest form it consists of two separate houses placed almost corner to corner so that their long axes form a right angle or two-sided semiclosed patio. Pits, ovens, burials, and other features occur both within and outside of the patio. Semiclosed household clusters excavated in 1972 to 1973 date from period Ic through IIIA and exhibit considerable variation. For example, we found a period II cluster with rooms around three sides of a patio but with ovens and a burial outside and downslope from the patio. We also found transition II–IIIA and IIIA clusters with flagstone patios and small stairways leading up from the patio either to adjacent rooms or to a backyard area. One IIIA cluster included burials below a patio floor and a large stone-lined pit adjacent to the patio.

The transition from open to closed household cluster seems to be accompanied by an increasingly formalized use of space between clusters. Judging from the 1972 to 1973 excavation data, contemporaneous household clusters at Monte Alban were established on separate natural terraces which differ in height by 1 or 2 m. Although we found period Ia clusters on adjacent terraces, the earliest construction relating two terraces is from period II and consists simply of stone steps built over a bedrock outcrop. The steps probably served for local traffic between households. A more formal arrangement is indicated by a period IIIB boulder stairway 1.5 m wide with balustrades, which occurs roughly midway between two IIIB household clusters. A boulder wall that may have functioned as a fence extends from one cluster to one balustrade. The stairway seems to have been part of a major or secondary public route rather than a local access between households.

The trend toward closed household clusters, compact cluster elements, and formal definition of space may be related to urban growth at Monte Alban. The site attained maximum size in period IIIB when most of the hilltop and slopes were covered by residences, public areas and buildings, and a network of roads and paths. The area excavated in 1972 to 1973 includes three period IIIB household clusters spaced approximately 25 m apart on separate terraces. I think this represents maximum occupation of the excavated area, although without finer chronological control it is difficult to prove that clusters of any given period were contemporaneous rather than sequential.

Table 1. Data on period IIIB household clusters from Monte Alban. Outer patio dimensions for type 2 clusters in parentheses.

| Building designation | Patio dimensions (m) | | Building dimensions (m) | | Source |
|---|---|---|---|---|---|
| | N–S | E–W | N–S | E–W | |
| | *Type 1 clusters* | | | | |
| 1. Monte Alban 1973, house 3 | 3.55 | 3.40 | | | (16) |
| 2. Building over "La Presa" | 3.65 | 3.45 | 9.40 | 9.30 | (*17*) |
| 3. Monte Alban 1972, main area | | 3.60+ | | | (*16*) |
| 4. Monte Alban 1972, area L, str. 1 | 3.75 | 3.70 | | | (*16*) |
| | *Type 2 clusters* | | | | |
| 5. Patio de las Tumbas 97 y 43 | 2.90(4.15) | 2.90(4.20) | | | (*13*, plan, p. 32f.) |
| 6. Sistema de las Tumbas 108:9 | 3.25(4.80) | 3.20(4.85) | | | (*13*, plan 19) |
| 7. Patio de las Tumbas 119–120 | 3.30(4.65) | 3.25(4.65) | 12.00 | 11.00 | (*17*) |
| 8. Patio al Sur del Templo del Vertice Geodesico | 3.80(5.05) | 3.85(5.10) | | | (*17*) |
| 9. Sistema del Entierro 66 | 3.85 | 3.85 | 12.30 | 13.85 | (*13*, plan 13) |
| 10. Plataforma Este Building south of El Palacio | (6.10) | (6.00) | 13.75 | | (*4*, plan 10) |
| | *Type 3 clusters* | | | | |
| 11. Sistema de la Tumba 104 | 9.20 | 10.00 | 20.75 | 20.00 | (*13*, plan 13) |
| 12. El Palacio (Plataforma Este) | 9.85 | 9.85 | 25.60 | 21.85 | (*4*, plan 10) |
| 13. Building beneath Patio de las Tumbas 119–120 | | | 22.00 | 22.00 | (*17*) |
| 14. Monticulo de la Piedra de Letra y Tumba 105 | 11.70 | 12.70 | 20.20 | 23.00 | (*13*, plan 18) |

## Household Cluster Standardization

Emergence of the closed household cluster is accompanied by standardization of cluster size and layout. Period I through IIIA clusters do not seem to exhibit strict patterning, although buildings are oriented according to the cardinal directions and contemporaneous clusters share distinctive construction details. House sizes and burial facilities vary as do kinds and placement of pits, ovens, and other features. In IIIB times, however, there are three standard variations on the basic pattern of rooms adjoining a square central patio. A sample of 14 household clusters is used to define the three types in terms of metric attributes (Table 1) and construction techniques.

*Type 1.* This is the small size and has a simple patio formed by a single line of faced stones. Examples excavated in 1972 to 1973 indicate that all four patio sides may not have been adjoined by rooms. Room walls and exterior house walls may have been built of wood or cane because stone foundations for adobe walls are not always present. Three of the four type 1 examples in the sample include extended supine burials in slab-lined graves, and in two of these three examples burials were found on the north side of the patio (Fig. 3).

*Type 2.* This is the medium size with a small inner patio surrounded by a bench which forms a larger outer patio (Fig. 4). Building exteriors are delimited by stone wall foundations which once supported adobe walls. One example in the sample (No. 5) was found with an extended supine burial in a slab-lined grave to the north of the patio, but additional burial data for type 2 household clusters are lacking.

*Type 3.* This is the large walled compound or palace (Fig. 5). Large tombs usually occur beneath one of the rooms and are entered by a stairway which descends from the patio. A wide stone stairway is sometimes found in front of the building, although entrance to the compound is usually through a narrow doorway.

Size differences between the types can be illustrated in three ways. First, examples shown in Figs. 3, 4, and 5 may be compared visually. Second, differences in patio areas by type can be shown graphically (Fig. 6) and, third, differences in patio areas can be compared statistically. As Table 2 indicates, the sum of the standard deviation of patio area calculated for each type is much less than the standard deviation calculated for the examples combined. This shows clustering in the data rather than a continuum, although the small sample size precludes use of a test of significance. The coefficients of variation (*10*) show that there is little variation among type 1 household clusters and relatively great variation among type 2 clusters. This might be a product of sample size, although the variation among type 2 examples may indicate that with additional data subtypes could be defined.

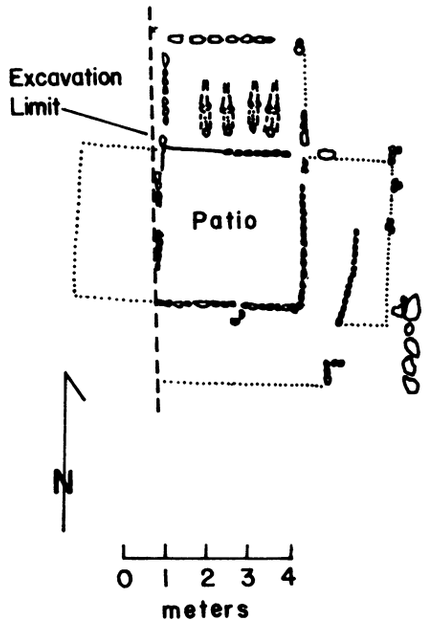


Fig. 3. A type 1, period IIIB household cluster excavated at Monte Alban in 1973 (Monte Alban 1973, house 3).

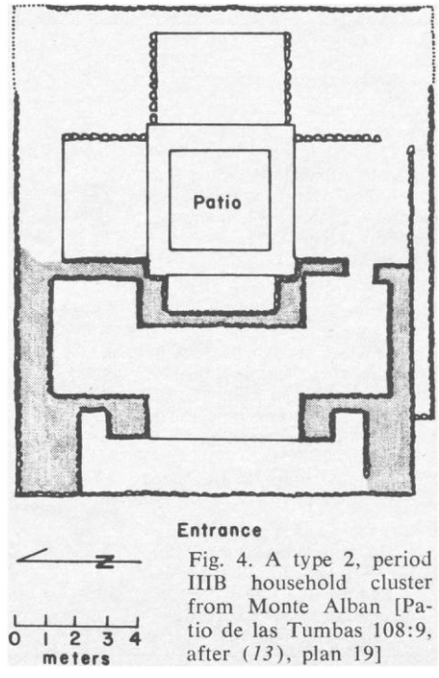


Fig. 4. A type 2, period IIIB household cluster from Monte Alban [Patio de las Tumbas 108:9, after (*13*), plan 19]

Period IIIB seems to be a time of standardization not only in household cluster size and layout but in other aspects of material culture. For example, period I and II ceramic figurines are handcrafted, and most ceramic bowls and serving vessels display incised or painted designs. Handmade figurines and decorated pottery are less common in IIIA times, and by IIIB all figurines seem to have been made in molds, painted or incised vessels being practically nonexistent.

## Status Differentiation

I have described three related trends in the residential data from Monte Alban, increasingly formal and structured use of space, increasing compactness of household cluster elements, and increased standardization in household cluster size and layout. Sociopolitical implications of these trends can be partly clarified by considering temporal variation in size and complexity of residential structures, elaborateness of burial treatment, and the degree of correlation between the two.

As early as period I there is evidence for size variation in residences at Monte Alban. Houses excavated in 1972 to 1973 are small rectangular stone foundations not exceeding 7.5 m long by 4.0 m wide. In addition, period I walls and floors were found in deep test pits dug into the north platform during earlier excavations (*4*, pp. 90–106). Although exposed horizontal areas were too small to determine dimensions or functions of the structures, location near the main plaza may indicate large elaborate residences. Perhaps the best example known of a period I residential structure that is clearly different from those recently excavated at Monte Alban is Platform 1 at the site of Barrio del Rosario Huitzo, which was described as follows (*8*, p. 32):

> . . . Platform 1 was composed of stone masonry walls several courses high, running E–W for at least 20 meters. The main north wall is flanked by a series of curious smaller walls which may constitute either (1) supports for a porch of some kind, or (2) a row of small (1.5 by 1.5 meter) storage units. . . . A superimposed series of white plaster floors extended north from the main wall and passed under the small "rooms"; none of the debris on these floors suggested that the building was of ceremonial function.

If the small community at Huitzo had at least one such residence in period I, the large important site of Monte Alban could be expected to have had a greater variety of types of residences.

Period I burials and tombs found at Monte Alban vary from those with individuals in simple graves with a single vessel to others, such as tomb 43, containing individuals in stone-constructed tombs with as many as 70 vessels. Recently uncovered was a period Ib tomb that was dug into bedrock and contained an adult male in extended supine position. There were 11 vessels and 33 beads and ornaments of marine shell in this tomb, which is part of a household cluster that includes a simple rectangular house structure. Although not as elaborate as tomb 43, the Ib tomb indicates that relatively elaborate burials do not necessarily occur with large complex residential structures. I assume that variation in period I burial treatment and in size of residences implies status differentiation, but the data are too sparse to demonstrate correlations and the meaning of the status differentiation is not clear.

Lack of information on variation in residential structures during periods II through IIIA again eliminates the possibility of demonstrating clear correlations between residence type and burial treatment. Several period II through IIIA tombs found in earlier excavations, such as tombs 6, 77, and 113, are elaborate in construction and contents, probably indicating a status category different from that represented by houses and burials found in 1972 to 1973. An excellent indication of a period II high-status group at Monte Alban is burial XIV-10. Five skeletons were found with grave goods including several hundred jade and greenstone beads, jade earspools, and a bat-god mask composed of pieces of jade and shell (*11*, pp. 22–23; *12*). High status is implied not only by quantity and quality of grave goods but by the fact that the burial was found in the main plaza, either in a public place or associated with a high-status residence.

In contrast to earlier periods, there is a clear correlation in period IIIB between burial treatment and size of residence. Type I household clusters are composed of small residences with burials containing adults extended supine in slab-lined graves, usually just to the north of the patio. Grave goods are meager or absent. Type 3 clusters include large walled residences with subfloor tombs. Some tombs have painted murals, fancy ceramic funerary urns, and many ordinary vessels (*13*, plans 15, 17). Residential structures of type 2 clusters are intermediate in size. One was found with an extended supine burial to the north of the patio (*13*, plan preceding p. 33), but I have no other data on burials associated with type 2 clusters. Since there are correlations between burial treatment and residence size and complexity for type 1 and type 3 clusters, I assume this is also true for type 2 clusters.

Period IIIB household cluster types can be interpreted as manifestations of three social classes. I suggest that residents of type 3 clusters—that is, the high-status individuals apart from servants or retainers who may have lived with them—were most probably the leaders of society, whether religious, secular, or some combination of the two. Residents of intermediate size clusters might have been of the lesser nobility or perhaps merchants, craftsmen, and artists. Inhabitants of type 1 household clusters may have been common laborers who owned their own houses, a characteristic which could have set them apart from a hypothetical class of slaves and servants for whom I have no household cluster data (*14*).

Two additional points are relevant to defining period IIIB classes. First, shell and greenstone ornaments are noticeably absent in the context of excavated type 1 household clusters, which indicates that such luxury items may have been distributed differentially according to class. The upper class probably received products and, by implication, controlled the labor of skilled craftsmen such as architects, painters, and makers of ceramic urns. In contrast, there was a much wider distribution throughout society of shell and greenstone ornaments and fancy vessels in periods I and II. Second, it may be significant that in the 1972 to 1973 excavations there was no clear evidence

Table 2. Patio area statistics for household clusters listed in Table 1. Outer patio dimensions were used to calculate patio areas for type 2 clusters. Clusters 9 and 13 are omitted because patio dimensions were not available. S.D., standard deviation; *v*, coefficient of variation.

| Building No. | Patio area ($m^2$) | Mean ($m^2$) | S.D. | *v* |
|---|---|---|---|---|
| | *Type 1 clusters* | | | |
| 1 | 12.07 | 12.88 | 0.66* | 5.1† |
| 2 | 12.59 | | | |
| 3 | 12.96 | | | |
| 4 | 13.88 | | | |
| | *Type 2 clusters* | | | |
| 5 | 17.43 | 24.94 | 6.44 | 25.8 |
| 6 | 23.28 | | | |
| 7 | 21.62 | | | |
| 8 | 25.75 | | | |
| 10 | 36.60 | | | |
| | *Type 3 clusters* | | | |
| 11 | 92.00 | 112.33 | 21.9 | 19.5 |
| 12 | 97.02 | | | |
| 14 | 148.00 | | | |
| | *All types of clusters* | | | |
| All | 513.00 | 42.77 | 42.63 | |

* The sum of the standard deviations of the three household cluster types taken separately is 29.00. † Standard deviation is divided by the mean times 100.

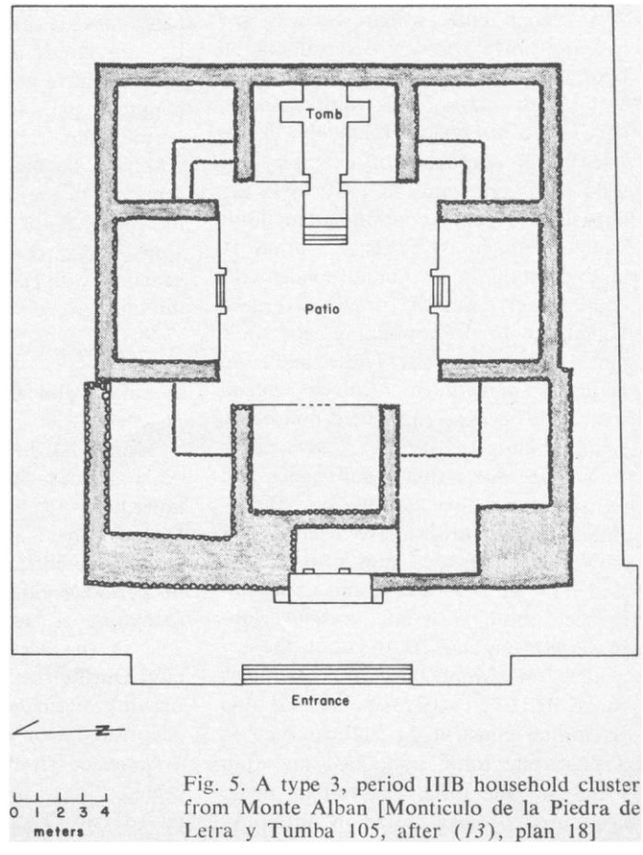


Fig. 5. A type 3, period IIIB household cluster from Monte Alban [Monticulo de la Piedra de Letra y Tumba 105, after (*13*), plan 18]

of storage facilities associated with type 1 IIIB household clusters. Most period I and II clusters include bell-shaped pits and one IIIA cluster that was excavated had a stone-lined cylindrical pit. If one assumes that these pits were used for storage of household grain supplies, by IIIB times either storage techniques had changed or some households did not store their own grain. The latter possibility may imply that these households formed a class of urban laborers distinct from food producers. It is apparent then from available residential data that status differentiation was present at Monte Alban from the earliest occupation, although not until the latest period is there evidence of distinct social classes.

There are three additional clues to the nature and basis of status variation at Monte Alban. One is the neighborhood hypothesis, or the possibility that unexcavated mound groups spaced at approximately regular intervals on the north slope of the site represent activity centers of high-status groups within separate neighborhoods. The mounds might be temples, administrative buildings, or large residences. Terraces between mound groups were excavated in 1972 to 1973, and evidence of only low- and middle-status households may have been recovered.

A second clue is that sex was apparently not a primary determinant of interhousehold status variation, since both adult males and adult females have been found in relatively elaborate burial context. For example, the following were found in 1972 to 1973: a period Ia tomb containing an adult female with four vessels, a period II tomb containing an adult female with eight vessels, and the previously mentioned Ib tomb containing an adult male and 11 vessels. These adult individuals may have received special treatment because they were household heads at time of death.

A third clue is that adult males and females were frequently buried together. Dual burials have been found at Valley of Oaxaca sites prior to period I (*3*, pp. 199–271), and apparently occur both with and without elaborate grave goods throughout the sequence at Monte Alban. Examples found in 1972 to 1973 include (i) two Ib tombs constructed end to end as a pair; one tomb contained an adult male and the other had either never been used or was looted in antiquity,

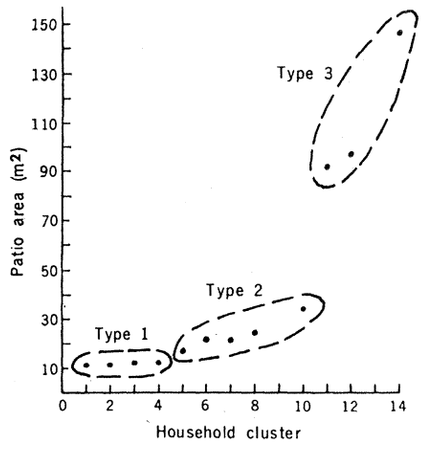


Fig. 6. Graph of patio areas of the sample of period IIIB household clusters. Patio areas were not determined for clusters 9 and 13, but they would be expected to fall within the loops outlined for their respective types.

(ii) a period II adult male and possible adult female in a common grave, and (iii) four IIIB individuals (two dual burials) found in one household cluster. Other examples of dual burials from Monte Alban include tomb 103 associated with a type 3 period IIIB household cluster (*13*, plans 13, 15), tomb 153 (*11*, p. 10) and burial XIV-10 (*12*, *15*). An obvious interpretation is that dual burials consist of conjugal pairs, although this has not been proved; siblings, master and slave, or unrelated individuals could conceivably have been buried together. The conjugal pair interpretation, if valid, would seem to constitute evidence for emphasis on marriage ties, the nuclear family, and the household, and it might indicate that for an adult these relationships took precedence over and superseded any lineage or other kinship affiliations.

## Summary and Conclusions

Monte Alban was founded in period I (about 500 B.C.) probably by households from previously existing villages in the Valley of Oaxaca. There is some evidence for status variation in period I households, but more information is needed to determine its role in the early development of the city. During the millennium or more of urban growth at Monte Alban a change occurred in the organization of household space from an open outward-directed focus to a closed inward-directed one. This was accompanied by a formalization of household and interhousehold space and by a standardization in household sizes and burial treatment reflecting emergence of a social class hierarchy. These changes indicate development from a flexible to a highly structured society, which may be a general trend in urbanization.

### References and Notes


1. An accurate population estimate for Monte Alban should soon be available based on an intensive surface survey made by R. E. Blanton, City University of New York.
2. There are several reasons for claiming that bell-shaped pits functioned primarily as storage facilities: (i) parallels exist in the ethnographic literature [see, for example, D. W. Hall, G. A. Haswell, T. A. Oxley, *Underground Storage of Grain* (Her Majesty's Stationery Office, London, 1956)]; (ii) experimental evidence shows the feasibility of underground storage techniques [see, for example, H. C. Bowen and P. D. Wood, *Bull. Inst. Archaeol.* **7**, 1 (19[illegible] D. E. Puleston, *Am. Antiq.* **36**, 322 (1971)]; (iii) analysis of pollen samples from floors of some bell-shaped pits at Tierras Largas in the Valley of Oaxaca indicated an unusually high percentage of corn pollen which may be evidence of storage of corn in the pits (see *3*, p. 137); (iv) variation in pit contents and placement of burials in pits indicates that pits sometimes functioned secondarily as refuse containers or graves (*3*, pp. 137–139, 207–208); (v) finally there is a negative argument that in household clusters where bell-shaped pits are found evidence of other kinds of storage facilities is lacking.
3. M. C. Winter, thesis, University of Arizona (1972).
4. A. Caso, I. Bernal, J. R. Acosta, *La Ceramica de Monte Alban* (Instituto Nacional de Antropologia e Historia, Mexico City, 1967).
5. New data on details of the Monte Alban sequence will be discussed in reports on the 1972 to 1973 excavations. Deposits dated as Monte Alban I-A in (*3*) can now be assigned to Rosario phase.
6. E. Rabin, *Bol. Estud. Oaxaqueños* **33**, 14 (1970).
7. J. Paddock, in *Ancient Oaxaca*, J. Paddock, Ed. (Stanford Univ. Press, Stanford, Calif., 1966).
8. K. V. Flannery, Ed., "Preliminary archaeological investigations in the Valley of Oaxaca, Mexico 1966–69" (a report to the National Science Foundation and the Instituto Nacional de Antropologia e Historia, mimeographed, 1970).
9. The closed household cluster may have been present among a restricted segment of society in the Valley of Oaxaca during the Guadalupe phase or earlier (*8*, pp 34–36), but not until period IIIB was it the predominant type.
10. H. Arkin and R. R. Colton, *Statistical Methods* (Barnes & Noble, New York, 1956), p. 40.
11. J. R. Acosta, *Informe de la XIVa. Temporada de Exploraciones de la Zona Arqueologica de Monte Alban 1945–46* (Archivo Tecnico de Monumentos Prehispanicos, Instituto Nacional de Antropologia e Historia, Mexico).
12. ———, *An. Inst. Nac. Antropol. Hist.* **3**, 17 (1949).
13. A. Caso, *Inst. Panam. Geograf. Hist. Publ. No. 34* (1938).
14. My interpretation of IIIB classes is similar to R. Spores' reconstruction of immediately pre-Conquest Mixtec society in *The Mixtec Kings and Their People* (Univ. of Oklahoma Press, Norman, 1967).
15. Adult individuals found in tombs 103 and 153 are not identified as to sex in the sources cited. Burial XIV-10 apparently consisted of two dual burials and a fifth unrelated individual. Dual burials constituted a small proportion of all burials and tombs found at Monte Alban, but it is the fact of occurrence rather than the frequency that is significant.
16. M. C. Winter, field notes made in 1972 to 1973.
17. Plan in archives of Centro Regional de Oaxaca, Instituto Nacional de Antropologia e Historia, Mexico.
18. The 1972 to 1973 excavations at Monte Alban

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# Multienzyme Systems of DNA Replication

## Proteins required for chromosome replication are resolved with the aid of a simple viral DNA template.

Randy Schekman, Alan Weiner, Arthur Kornberg

Template direction of nucleic acid synthesis was seen first in DNA synthesis catalyzed by DNA polymerase and only later was observed in RNA synthesis by RNA polymerase. Nevertheless, work on RNA polymerase during the last 10 years has explained key physiological features of transcription (*1*), whereas the reconstruction in vitro of replication by DNA polymerase action alone has remained inadequate. The basis for this discrepancy in progress is rooted in a biochemical fortuity. By means of enzyme fractionation procedures, RNA polymerase was isolated from cell extracts as a large multisubunit transcriptase. Isolated DNA polymerase, on the other hand, is only one component of a multienzyme DNA replicase. The purpose of this article is to describe the first stage in our efforts to identify and reassemble the pieces of this multienzyme system.

*Polymerase actions.* The basic elements in synthesis of a nucleic acid are the same whether the chain produced is DNA or RNA, and whether template directions are taken from DNA or RNA (*2*). Elongation of a 3′,5′-phosphodiester-linked polynucleotide invariably has these features: (i) Substrates are a 3′-hydroxyl terminated chain (primer terminus) and a 5′-nucleoside triphosphate. Nucleophilic attack by the primer terminus adds a 5′-nucleoside monophosphate to the chain. (ii) Selection of the specific triphosphate depends on its forming a Watson-Crick base pair with the template. (iii) Growth of the chain is necessarily in a 5′ → 3′ direction, antiparallel to the template.

Among the more than 20 DNA polymerases of viral, bacterial, and animal origin isolated to date, none can start a chain in vitro. This feature distinguishes DNA polymerases most clearly from RNA polymerases. The essence of transcription is the highly selective copying of passages from the chromosome record, and the capacity of RNA polymerases to start chains at defined "promoter" sequences is a prominent part of its function. Thus, DNA polymerases, remarkable for their error-free copying of the entire chromosome, are apparently blind to initiation signals, including the one promoting the origin of a replication cycle. Until recently the enzymatic mechanism of starting DNA chains remained an enigma.

*The chain initiation enigma.* Two kinds of DNA chain starts need to be considered: (i) initiation of chromosome replication at its unique origin, and (ii) initiation of the short replication fragments that are synthesized discontinuously (Okazaki pieces) at the growing fork or nascent region of the chromosome. This distinction is indicated by genetic and biochemical experiments. Several *Escherichia coli* mutants, thermosensitive in DNA replication [*dna*A and *dna*C (*3*), and, more recently, *dna*H and *dna*I (*4*)], are defective in initiating replication at the chromosome origin. They are unlike other mutants [*dna*B, *dna*E, and *dna*G (*3*)] whose DNA replication stops abruptly when the temperature is raised to a restrictive level; the origin-defective mutants continue DNA synthesis until the chromosome duplication under way is completed. Among the abrupt-stop mutants, *dna*G has been implicated in nascent chain starts (*5*) and *dna*E shows a defect in DNA polymerase III (*6*). Fruitful as these genetic studies are, elucidating the mechanism of chain initiation requires a biochemical approach.

Discovery of these numerous thermosensitive, *E. coli* replication mutants illustrates the multiplicity of gene products needed for chromosome replication. This was anticipated since the phage T4 chromosome, only a twentieth the size of *E. coli*, still induces formation of at least six proteins essential for its replication. We now find from our studies reported below that much of the complexity of the replicative machinery resides in the events of chain initiation. This recent progress is based on two things: the use of small phage chromosomes as probes and the development of a cell extract consisting of soluble enzymes and capable of phage chromosome replication.

*Phage probes and soluble enzymes.* Attempts to understand how DNA chains are started and elongated had been frustrated by the use of large chromosomes, such as those of bacteria and medium-sized phages, and, in addition, by the fragmentation of the multienzyme replication system. Enzymological studies have been greatly aided by the use of the single-stranded (SS) circular chromosome of the small DNA phages (*2*).

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