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Transformations Models

The consideration of cultural formation processes in the previous chapters has led to an appreciation for the differentiated nature of archaeological remains and also a reevaluation of generally accepted assumptions about how the archaeological record is produced. Statements to the effect that the patterning of remains in a site directly reflects the structuring of past activities and social groups there can be abandoned decisively now. The more realistic principle is that the structure of archeological remains is a distorted reflection of the structure of material objects in a past cultural system. Such distortions are caused by cultural and non-cultural formation processes. These distortions are taken into account and corrected by constructing appropriate conceptual and methodological tools to act as lenses through which the structure of the past can be perceived by observing the structure of the present. Just as all information needed to produce a sharp print is encoded in even the most poorly focused negative, the information for reconstructing the past is encoded in the structure of the present—but, instead of applying holographic restoration techniques, we apply c-transforms, n-transforms, and justifiable stipulations to eliminate the distortions introduced by formation processes.

STRUCTURES OF THE PAST AND PRESENT

The structure of the archeological record at a site—as it is perceived by the archeologist—can be described more precisely. It consists of material objects, features, and residues in a static, three-dimensional spatial arrangement. A complete description of the present structure also includes materials that were deposited by the operation of non-cultural formation processes, such as soil. Thus, besides artifacts and ecofacts (Binford 1964), purely environmental facts of interest are contained within the present structure of the archeological record. Such a structure is described in terms of quantitative, formal, spatial, and relational properties of the various constituent materials.

The past structure of material objects also can be described by spatial, quantitative, formal, and relational variables. But such a description is very different from the static structure of the present. Systemic structures are synchronic slices of a dynamic system. Variability and change in the past are caused by the operation of energy sources, such as humans or machines, which effect changes in the quantitative, spatial, relational, and formal variables. For example, the formal properties and spatial locations of an object vary according to the systemic process under consideration. Naturally, events of the systemic structure occur at different times and the temporal parameter often must be considered.

It must be emphasized that there is no single systemic structure; there are many, depending on the interests of an investigator. For example, Wilcox (1975) introduces the useful concept of “site structure,” defined as the set of all occupation surfaces that were in contemporary use in the past. This concept can be applied flexibly at different scales. (The flooring-over of a pit may or may not signify a change in the site structure, depending on how one defines the units of activity space.) The site structure is only one of many concepts that pertain to the complex systemic structure.

TRANSFORMATIONS

Quite clearly, the structures of the past and present are not equivalent; and this fact poses the basic problem faced by all archeologists: How does one relate the archeological and systemic structures? Although one might be tempted to suggest that this is achieved by “transforming” the archeological structure into a systemic structure, this is true only in a metaphorical sense. The task is one of modeling the transformations wrought by formation processes on systemic materials to produce the archeological structure. When one successfully models or specifies the nature and effects of these processes, then, and only then, can the two structures be related. Throughout the remainder of this work, reference is made to “transformations.” It should be understood that, in “transforming” the present into the past, one is accounting for the transformations of the past into the present by formation processes.
All archeologists make assumptions about the cultural and noncultural formation processes that have operated to produce the materials being studied. Usually, these assumptions are implicit, and only on rare occasions have they been subjected to scrutiny, discussion, and testing. Unfortunately, many of these transformations, upon which the success of one's reconstructions depends, are ill-founded, and their use—implicitly and explicitly—for explaining the archeological structure and deriving information about the past has led to erroneous questions, sometimes spurious inferences, and a seeming ignorance of the complexity of the transformation problem itself.

Equivalence Transformation

The single most common inappropriate transformation is known as an equivalence transformation (Schiffer 1973a:73). An equivalence transformation asserts an identity between variables of the archeological and systemic structures. Several examples will illustrate the nature and pitfalls of this type of transformation.

It is tempting to assume that artifacts spatially associated in archeological context were associated also in systemic context, especially during use. Discussions in the preceding chapters should have indicated why this will be so only in some situations (see also Jelks 1972). Another equivalence transformation states that archeological quantities are related directly to systemic quantities; for example, some have assumed that, because there are 20 bowls per jar archeologically, there were 20 bowls in use for every jar. Because many other variables intervene, however, this is clearly a risky, and usually erroneous, transformation. More complex quantitative variables, such as frequency distributions, also have been subjected to equivalence transformations. Another type of equivalence transformation involves the assumption that variability in the formal properties of archeological remains directly corresponds to systemic variability. For example, projectile point types, often defined on the basis of shape and characteristics of the haft area, are assumed to correspond to past social or temporal variables. In recent studies, formerly distinct projectile point types have been shown to represent simply different degrees of maintenance and recycling processes (e.g., Goodyear 1974).

What archeologists have failed to note previously is that equivalence transformations are a special, not a general, case. A consideration of formation processes and the need to keep the archeological and systemic contexts conceptually distinct forces us to recognize that, in most instances, variables in the archeological structure have been transformed considerably from their values in the systemic structure. Thus, all transformations are non-equivalent; however, in some few instances, the degree of nonequivalence may be trivially small.

Equivalence transformations usually reflect an implicit merging by an investigator of the archeological and systemic contexts. This habit of thought also is reflected in a welter of terminological confusion which has hindered efforts to construct reliable transformation procedures (see Reid 1973:21–24). Many of our terms, such as “room,” “site,” and a host of functional names for artifacts, are indiscriminately used to designate both archeological and systemic context phenomena. To relieve archeology of this conceptual messiness and to facilitate construction of reliable transformation models, it is necessary to use terms that apply unambiguously to one context or the other (see Schiffer 1973a:77–88 for examples of mixed-context terms). I begin this process by presenting several of the systemic terms used throughout this and the remaining chapters.

SOME BASIC TERMS

The principal unit of archeological observation is the artifact. An artifact, in systemic context, is an element. I define elements to include foods, fuels, tools, facilities, machines, and human beings. Provisionally, elements can be divided into the categories of durables, consumables, and energy sources (Schiffer 1972b). Durables are tools, machines, and facilities—in short, transformers and preservers of energy (Wagner 1960). Consumables are foods, fuels, and other similar elements whose consumption results in the liberation of energy. Elements of both kinds often are joined physically to form more complex elements; and, of course, raw materials of one sort or another are combined or separated to form elements. When broken, elements become fragments. An energy source, such as a human being, is capable of performing work, thus expending energy.

The basic unit of behavior is the activity. An activity is defined as the interaction between at least one energy source and one cultural element (Schiffer 1972b:157). An activity structure consists of all activities participated in by a designated social unit (this definition differs slightly from my earlier use of the term “activity structure,” (Schiffer 1972b:157)). For example, one can discuss the activity structure of a community (which may or may not be isomorphic with the activities performed at a site) or the activity structure of a nuclear family.

A location of activity performance is termed a locus (Binford 1964). An activity set (Stuever 1968:135) consists of all activities repetitively performed within a specified unit of space, which is called an activity area (Stuever 1968:135) and is made up of the loci of individual activity performance. For some purposes, an entire site may be considered an activity area, whereas smaller units of space are more appropriate for other problems.
FLOW MODELS

Perhaps the simplest way to solve the transformation problem is to focus on the life history of elements in systemic context. The sequence of activities in the systemic context of any durable element can be grouped into a set of basic processes and represented by a flow model (Schiffer 1972b). These processes include procurement, manufacture, use, maintenance, and discard. A process consists of one or more stages, such as the stages in the manufacture of a clay vessel. A stage, in turn, consists of one or more activities. Activities are discussed further in Chapter 7.

The terms describing the processes within the systemic context of consumable elements are parallel to, and adapted from, the flow model of durable elements. They are procurement, preparation, consumption, and discard (Schiffer 1972b). For the sake of convenience, the discussions to follow make exclusive use of the processes of durable elements.

In addition to the five basic processes of systemic context, it is necessary for some problems to consider storage and transport, activities that provide, respectively, a temporal and spatial displacement of an element. Transport and storage may take place singly or in combination between any two processes, stages, or activities of a stage.

Some items undergo a more devious set of processes within their systemic context. Elements can be rerouted at strategic points to processes or stages through which they already have passed. This general condition is known as

![Figure 4.1 Flow model for durable elements. Key: --- system under analysis; - - - opportunity for storage and/or transport. (From Schiffer 1972b.)](image)

Figure 4.1 Flow model for durable elements. Key: --- system under analysis; - - - opportunity for storage and/or transport. (From Schiffer 1972b.)

and includes the various S-S processes discussed in the previous chapter. Figures 4.1 and 4.2 illustrate the basic flow models for durables and consumables, respectively, by which the coarser aspects of any element's systemic context can be described. It is up to the individual investigator to modify the model as appropriate for specific materials and questions.

To date, flow models have been used principally to handle the transformation problem with respect to chipped-stone artifacts. Muto (1971) and Collins (1971, 1974) have pioneered these efforts, and other investigators now are following suit (e.g., Shaffer 1973; Schiffer 1973a; Gregg 1974). Perhaps the most ambitious use of flow models in lithic research is House's (1975) treatment of the Cache Basin assemblages of northeast Arkansas (Figure 4.3). In all of these examples, a description of the technological processes was the problem at hand, and, thus, although cultural formation processes are considered to some extent, no instance is the treatment exhaustive. In future applications of flow models, it should be possible to account for all relevant cultural formation processes.

Flow models are particularly well-suited for characterizing productive technologies like chipped-stone industries. In addition, they can be coupled with experimental data produced by modern flintknappers for constructing quantitative models. These kinds of research are in their infancy, but major discoveries stand poised in the wings. Further research will reveal whether or not flow models can be used efficiently for solving the transformation problem on other cultural materials. Flow models also can be quantified directly, as will be shown in Chapter 5.

![Figure 4.2 Flow model for consumable elements. Key: --- system under analysis; - - - opportunity for storage and/or transport. (From Schiffer 1972b.)](image)
BEHAVIORAL CHAINS

A second type of transformation model is the behavioral chain, used to systematize activity hypotheses and generate their test implications. A similar but more specific model has been put forward by Kroeber and Thorne (1971; see also Fritz 1974). The perspective of Harris (1964) was utilized in the development of the behavioral chain model (Schiffer 1975a). I have substituted for his actor-activity orientation an artifact-activity orientation, which is more appropriate for archaeological uses.

A behavioral chain is the sequence of all activities in which an element participates during its systemic context (Schiffer 1975a). Behavioral chains may be divided into designated portions called segments, of which the smallest is a single activity. Behavioral chain segments may be defined to correspond to gross system processes, as described in the previous section, but they need not be. Each activity is defined by seven components:

1. A specific behavioral description of the activity;
2. The nature of the constituent human and nonhuman energy sources;
3. The element(s) conjoined or associated with the one under consideration;
4. The time(s) and frequency of activity performance;
5. The locus of activity performance;
6. Points at which other elements integrate with, or diverge from, the element under consideration;
7. The pathways created to the archeological record by the outputs of activity performance.

These essential components of any activity now are given more explicit definition. The examples in the following discussion refer to a behavioral chain segment for Hopi maize, derived from ethnographic sources (Figure 4.4). Where no authors are cited specifically for the information listed under an activity component, I simply have made a reasonable guess in the absence of the relevant data.

Activity Definition

The nature of the activity is one of the most important components. Activities should be described in terms of the dynamic relationships among the participating elements. For example, use of the term "grinding" is an attempt to be precise in designating a set of behaviors. Grinding implies that the object of the activity, such as maize, is being worn down by the application of a tool. Because the attributes of tools make them more or less suitable for behavior in a certain way, the precise specification of a behavior can lead to a listing of the attributes a conjoined element must have possessed (or acquired through use). These inferences are made possible by application of correlates that state relationships.

Figure 4.3: Flow model for prehistoric chipped stone of the Cache River Basin, Arkansas.
between morphological attributes of objects and behavior, and the results of behavior in terms of use-related attributes. Naturally, this kind of activity definition can lead to the construction of test implications for any hypothesized activity (when coupled to the relevant transforms or transform stipulations).

### Energy Sources

The number and nature of human energy sources are a designation of the social unit of activity performance (Freeman 1968). This unit consists of any and all humans associated with the element during a specific activity. The concept of social unit of activity performance applies minimally on two levels: the individual and the societal level which is recurrent. For example, it might be pointed out that, among the Hopi, a post PUBESCENT woman does the coarse-grinding of maize. At another level of analysis, it may be desirable to specify that the social unit of coarsely grinding maize is all post PUBESCENT women of a society; in this case, a status is specified. It also should be possible to consider and describe patterned internal variability in a society for a social unit of activity performance.

Nonhuman energy sources include the sun, wind, fire, animals, and machines.

### Conjoined Elements

The conjoined elements are those (excluding energy sources) associated with the one under consideration during the activity. They should be conceived of in terms of the attributes critical to their interaction. This implies that not all attributes of form are relevant for the description of an element or its identification.

### Times and Frequency

Reference is made here to the class of usual performance times and frequencies (with the stipulation that variability can be encompassed in specific applications). As an example, among the Hopi, the activity of metate stone procurement took place yearly in the winter (Bartlett 1933).

### Locus

The locus of activity performance ordinarily refers to a location or class of like locations within an activity area; they can be specified relative to each other or with respect to stationary objects.

### Chain Intersections

In constructing the behavioral chain of an element, it is necessary for some problems to specify when another element has become attached to, or deleted from, the reference chain. For example, spices and other ingredients become

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**Figure 4.4** Behavioral chain segment for Hopi maize. Key: 1 = Bartlett (1933); 2 = Bartlett (1938); 3 = Beuclerk (1937); 4 = Stephen (1930); 5 = Turner and Lofgren (1968); 6 = Whiting (1930); H.H. = household. (From Schiffer 1978a.)

<table>
<thead>
<tr>
<th>Activity</th>
<th>Energy Sources</th>
<th>Conjoined Elements</th>
<th>Time and Frequency</th>
<th>Location</th>
<th>Outputs</th>
<th>Intersections</th>
<th>Additions</th>
<th>Deletions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harvest</td>
<td>Able women</td>
<td>Baskets, hoppers</td>
<td>Several days in September</td>
<td>Fields of H.H.</td>
<td>Stocked, wasted</td>
<td>Selections</td>
<td>Additions</td>
<td>Deletions</td>
</tr>
<tr>
<td>Transport</td>
<td>Able women</td>
<td>Baskets, hoppers</td>
<td>Once in September</td>
<td>Fields of H.H.</td>
<td>Stocked, wasted</td>
<td>Selections</td>
<td>Additions</td>
<td>Deletions</td>
</tr>
<tr>
<td>Husk</td>
<td>Women of H.H.</td>
<td>Hoppers, pest</td>
<td>Once in September</td>
<td>Fields of H.H.</td>
<td>Stocked, wasted</td>
<td>Selections</td>
<td>Additions</td>
<td>Deletions</td>
</tr>
<tr>
<td>Dry</td>
<td>Women of H.H.</td>
<td>Hoppers, pest</td>
<td>Once in September</td>
<td>Fields of H.H.</td>
<td>Stocked, wasted</td>
<td>Selections</td>
<td>Additions</td>
<td>Deletions</td>
</tr>
<tr>
<td>Storage</td>
<td>Women of H.H.</td>
<td>Baskets, hoppers</td>
<td>In storage</td>
<td>Fields of H.H.</td>
<td>Stocked, wasted</td>
<td>Selections</td>
<td>Additions</td>
<td>Deletions</td>
</tr>
<tr>
<td>Transport</td>
<td>Women of H.H.</td>
<td>Baskets, hoppers</td>
<td>Once in September</td>
<td>Fields of H.H.</td>
<td>Stocked, wasted</td>
<td>Selections</td>
<td>Additions</td>
<td>Deletions</td>
</tr>
<tr>
<td>Remove Kernels</td>
<td>Women of H.H.</td>
<td>Hoppers, pest</td>
<td>Several days in September</td>
<td>Fields of H.H.</td>
<td>Stocked, wasted</td>
<td>Selections</td>
<td>Additions</td>
<td>Deletions</td>
</tr>
<tr>
<td>Corneal</td>
<td>Women of H.H.</td>
<td>Hoppers, pest</td>
<td>Several days in September</td>
<td>Fields of H.H.</td>
<td>Stocked, wasted</td>
<td>Selections</td>
<td>Additions</td>
<td>Deletions</td>
</tr>
<tr>
<td>Grind</td>
<td>Women of H.H.</td>
<td>Hoppers, pest</td>
<td>Several days in September</td>
<td>Fields of H.H.</td>
<td>Stocked, wasted</td>
<td>Selections</td>
<td>Additions</td>
<td>Deletions</td>
</tr>
<tr>
<td>Remove Chaff</td>
<td>Women of H.H.</td>
<td>Hoppers, pest</td>
<td>Several days in September</td>
<td>Fields of H.H.</td>
<td>Stocked, wasted</td>
<td>Selections</td>
<td>Additions</td>
<td>Deletions</td>
</tr>
<tr>
<td>Medium</td>
<td>Women of H.H.</td>
<td>Hoppers, pest</td>
<td>Several days in September</td>
<td>Fields of H.H.</td>
<td>Stocked, wasted</td>
<td>Selections</td>
<td>Additions</td>
<td>Deletions</td>
</tr>
<tr>
<td>Fine</td>
<td>Women of H.H.</td>
<td>Hoppers, pest</td>
<td>Several days in September</td>
<td>Fields of H.H.</td>
<td>Stocked, wasted</td>
<td>Selections</td>
<td>Additions</td>
<td>Deletions</td>
</tr>
<tr>
<td>Storage</td>
<td>Women of H.H.</td>
<td>Hoppers, pest</td>
<td>Several days in September</td>
<td>Fields of H.H.</td>
<td>Stocked, wasted</td>
<td>Selections</td>
<td>Additions</td>
<td>Deletions</td>
</tr>
<tr>
<td>Transport</td>
<td>Women of H.H.</td>
<td>Hoppers, pest</td>
<td>Several days in September</td>
<td>Fields of H.H.</td>
<td>Stocked, wasted</td>
<td>Selections</td>
<td>Additions</td>
<td>Deletions</td>
</tr>
<tr>
<td>Make Quern</td>
<td>Women of H.H.</td>
<td>Hoppers, pest</td>
<td>Several days in September</td>
<td>Fields of H.H.</td>
<td>Stocked, wasted</td>
<td>Selections</td>
<td>Additions</td>
<td>Deletions</td>
</tr>
<tr>
<td>Cook</td>
<td>Women of H.H.</td>
<td>Hoppers, pest</td>
<td>Several days in September</td>
<td>Fields of H.H.</td>
<td>Stocked, wasted</td>
<td>Selections</td>
<td>Additions</td>
<td>Deletions</td>
</tr>
<tr>
<td>Serve</td>
<td>Women of H.H.</td>
<td>Hoppers, pest</td>
<td>Several days in September</td>
<td>Fields of H.H.</td>
<td>Stocked, wasted</td>
<td>Selections</td>
<td>Additions</td>
<td>Deletions</td>
</tr>
<tr>
<td>Eat</td>
<td>Women of H.H.</td>
<td>Hoppers, pest</td>
<td>Several days in September</td>
<td>Fields of H.H.</td>
<td>Stocked, wasted</td>
<td>Selections</td>
<td>Additions</td>
<td>Deletions</td>
</tr>
<tr>
<td>Defecate</td>
<td>Women of H.H.</td>
<td>Hoppers, pest</td>
<td>Several days in September</td>
<td>Fields of H.H.</td>
<td>Stocked, wasted</td>
<td>Selections</td>
<td>Additions</td>
<td>Deletions</td>
</tr>
</tbody>
</table>
part of the maize behavioral chain during "dumpling preparation" activities. In the case of divergence, one can cite the separation of kernels and cob (Figure 4.4).

**Outputs or Pathways**

At every point in the behavioral chain that is labeled "output," a path exists through which materials may become part of the archeological record. This includes waste products and elements that terminate their use life during activity performance. In the case of some outputs, such as pollen grains and seeds lost during storage, the material may undergo no further cultural transport or discard. Other pathways are more complex. For example, waste produced from cooking or mixing activities constitutes an obvious inconvenient and unsanitary residue that most likely would be cleaned up, transported, and discarded as secondary refuse. In societies with highly developed refuse disposal systems, most elements make their way into the archaeological record at locations other than those of their use, and it is necessary to specify in the appropriate component of the behavioral chain exactly how and where these discard activities take place. (Data are incomplete in the Hopi maize example.)

As the Hopi maize example illustrates, behavioral chain models are especially useful where ethnographic data are available. It should be noted, however, that no ethnographic observations were available for over half the entries in Figure 4.4. Further, the lack of archeologically relevant data in ethnographic reports is systematic. The likelihood of finding ethnographic observations on a component decreases in the following order: conjoined elements, energy sources, location, time and frequency, and outputs. Not surprisingly, a similar pattern of ethnographic reporting bias has been found repeatedly in other attempts to construct behavioral chains (Magers n.d.; George and Rose 1973; Clessen 1975). The archeologist relying on ethnographic data to build behavioral chains will have to make educated guesses at many components. Generalized behavioral chains, based on correlates, eventually may be constructed to obviate partially this difficulty. Elsewhere, I have presented several correlates that can be used to expand the corpus of activity hypotheses (Schiffer 1975a:142-144).

The use of behavioral chains, once constructed, is relatively informal. An attempt is made to match the output components of each activity with available archeological evidence. A close fit between expectations and observations results in the retention of an activity hypothesis, and a poor fit results in hypothesis rejection or modification (e.g., site n.d.; Magers n.d.). The matching process is not carried out in a rigidly prescribed manner but is flexibly applied to allow consideration of multiple lines of evidence.

Several investigators have added significant elements to the construction and use of behavioral chain models. Rock (n.d.) has formulated the concepts of conjoined chain and alternative chain segment. A conjoined chain covers what I have referred to as "chain intersections." It may be divergent (for instance, maize cobs after separation from kernels) or convergent (say, spices when added to dumplings). An alternative chain segment is a substitutable portion of a chain. For example, after maize is ground into meal, it can be prepared in several different ways. These additional sequences of cooking activities are alternative chain segments.

In the report on the El Sol-Vall Transmission Line Project, Phillips has adapted the behavioral chain model for site wise use. He attempts to describe the past interaction between sites on the basis of the flow of materials and the differentiation of activities. To operationalize this approach, he defines two types of behavioral chains:

1. a site-continuous behavioral chain, in which the life history of an element occurs entirely at one site, and
2. a site discontinuous chain, in which only part of the element's life history occurs at one site...[McDonald et al. 1974:136; emphasis mine].

Use of these concepts for different elements allows precise behavioral characterizations to be made of components in a past settlement system as required for studies of cultural adaptation.

It seems that the behavioral chain model lends itself to a wide variety of applications, most of which have yet to be explored. As more applications are attempted, it will become easier to gauge its areas of usefulness and limitations.

**THE PATHWAY MODEL**

Behavioral chain models force one to consider individual activities as generators of archeological remains; that is, the performance of an activity can be viewed in terms of its potential contribution to the archeological record. Activities, then, create pathways to the archeological record. The pathway model is an outgrowth of behavioral chain analysis (Schiffer 1975a), and is simply a more formalized and quantified version of the output component of the behavioral chain model. Because it can be used separately from behavioral chains and because it too can be engaged in a variety of important uses, especially the production of simulated data, I treat the pathway model separately. In addition, it was my failure to differentiate the two models, in an earlier discussion, that resulted in cumbersome and unnecessary shifts in the frame of reference from activities to elements back to activities (Schiffer 1973a:117-123).

To begin, it is noted that many pathways do not lead directly to archeological context, because of the occurrence of lateral cycling, recycling, and other processes (Schiffer 1972b, 1973a, 1975a). Further, decay and other noncultural formation processes can effect additional transformations. Nevertheless, a gen-
eral equation can be provided that describes the pathways initiated by activity performance, and other terms introduced to allow for the operation of some subsequent processes.

If each instance of activity performance is defined as one use for all constituent elements (except consumables and waste products), then the quantity of any element type terminating its usefulness during an instance of activity performance may be expressed as follows:

\[ C = \frac{1}{b} \]  

(1)

where

\( C \) = the quantity of an element type exhausted during one instance of activity performance. This variable is termed the output fraction.

\( b \) = the number of uses per usefulness. The quantity \( b \) is statistical and designates an average number of uses.

As a result of this relationship, one instance of activity performance creates the following pathways to the archaeological record:

\[ Y = r_1C_1 + r_2C_2 + \ldots + r_nC_n \]  

(2)

where

\( Y \) = the total number of exhausted elements of each type \( 1 \ldots n \);

\( C_1 \ldots C_n \) = the respective output fractions of all elements \( 1 \ldots n \) of an activity;

\( r \) = coefficient of recycling;

\( d \) = coefficient of decay (or other non-cultural loss).

Thus, the total pathways \( Z \) created by one instance of performance of an activity set is equal to

\[ \Sigma Y \]  

(3)

Because the performance rates of the activities that comprise an activity set are likely to vary, a more useful expression takes into account both the duration and rate of activity performance. To construct this equation, several more items must be introduced. The activities of any activity set are \( A_1 \ldots A_n \), and the performance rates of each are represented as \( F_{A_1} \ldots F_{A_n} \). In addition, let \( t \) equal the interval of time over which an activity set is conducted. The total pathways formed by the operation of an activity set during time \( t \) can be expressed as

\[ Z = t(YF_{A_1} + YF_{A_2} + \ldots + YF_{A_n}) \]  

(4)

A principal use of the pathway model is the generation of simulated data for evaluating analytic techniques and testing other transformation models (Schiffer 1975b). Other uses might include more formal applications of behavioral chain models. For example, as experimental and ethnographic data accumulate on uselives and other systemic variables, it will be possible to offer a precise set of archaeological predictions for any set of activities. One could change the value of various variables, such as duration of activity performance or relative performance frequencies, to provide even closer fits to the observed quantities of artifacts in archeological context. It seems safe to predict that the pathway model and as yet undeveloped analogs will become extremely important in future studies of archeological context variability (see also Schiffer 1975c).

**THE REID TRANSFORMATION MODEL**

From discussions in preceding chapters, it should be clear that the materials produced by differing formation processes may be appropriate for answering different kinds of questions. In the most obvious example, a study of textiles scarcely would be carried out on sites where conditions did not favor their preservation. In another example, it would not be desirable to compare primary and de facto refuse from one site with the secondary refuse from another if the problem consisted in discussing variations in abandonment behavior. Nor would it be wise to take secondary refuse locations as directly indicative of activity locations within a site. These examples relate to the important question of establishing comparability among units of analysis. The criteria for establishing comparability is the focus of the Reid model (Reid 1973; Reid, Schiffer, and Neff 1975; Schiffer 1973a; Reid and Schiffer n.d.). It is billed as a general transformation model, and, indeed, it very likely subsumes the others that have been presented. The basis of the model is that transformation procedures must explicitly identify and model the processes responsible for the archeological remains under study within specified analytic units.

The presentation of this model requires the introduction of additional technical terms (this discussion closely follows Reid and Schiffer n.d.). **Transformation procedures** are the application of the general conceptual toolkit (correlates, c-transforms, and n-transforms) to the pragmatic problems of archeological research. These applications are directed toward establishing relationships between the systemic context and archeological context relevant to the solution of research problems on a specific body of archeological data. Research problems are framed within the systemic context of information, which includes specific behavioral and cultural variables of the past that are the objects of archeological descriptions and explanations. These variables, not directly observable in the archeological record, are related through systemic transformations to specific units of analysis, which, in turn, are operationalized to units of observation in the archeological context by identification transformations. Systemic transformations relate systemic context information to units of analysis, and are facili-
An Example: Curate Behavior

In studying the Nunamiat Eskimo throughout the seasonal round, Binford identified what he calls curate behavior, which consists of removing objects from one site and transporting them elsewhere in anticipation of future use (Binford 1973). It should be recognized that curate behavior occurs to a certain extent in all cultural systems; very few activity areas are abandoned with a complete inventory of cultural elements left as de facto refuse. Suppose, then, that an archeologist asked the following systemic context question of a site: What items did the occupants carry off elsewhere? In other words, what items were curated? If problems of recycling, preservation, occupation span, and systemic change are eliminated from this example, a fairly straightforward set of transformations yields the desired answer.

The basic systemic transformation (adapted from Reid 1973:27–28) is the following:

\[ C = (P + S) - D \]

where
- \( P \) = set of element types in primary refuse;
- \( S \) = set of element types in secondary refuse;
- \( D \) = set of element types in de facto refuse;
- \( C \) = set of curated element types.

The set \((P + S)\) consists of an inventory of normal system outputs and thus provides an inventory of element types used at the site. De facto refuse consists of the residual element set after curated elements are removed from the total inventory. This transformation specifies that an inventory of cultural element types from each kind of refuse must be acquired.

The problem remaining is to predict the locations of, or to identify the deposits of, each type of refuse at the site under study. In other words, the analytical units—element sets within refuse types—must be related to actual observational units (proveniences). This involves construction of identification transformations. For example, one type of primary refuse produced is burial goods, which are identified readily in archeological context. Secondary refuse consists of worn-out and broken materials and usually occurs in deposits of high material density and diversity. De facto refuse is found in the last-occupied activity areas, which are identified through another set of transformations. Having located and inventoried the element types contained within each kind of refuse, the archeologist feeds these element sets into the above-mentioned systemic transformation and derives the set of curated elements.

In principle, the simplest transformations are those whose analytic units are operationalized to the observational unit “site.” Many quantitative estimates of systemic properties, such as dependence on specific resources, utilize “community” or “settlement” as the analytic unit. These units generally are defined as all the refuse produced by a social unit at one location. Thus, single-component sites are the appropriate observational unit. Grahame Clark’s (1954, 1972) studies at Star Carr provide one of the most successful examples of this kind of transformation. Although the identification transformation is quite simple, the six-stage systemic transformation used to relate aspects of prehistoric diet to animal bones is quite complex (see Shawcross 1972 for an outline of Clark’s systemic transformation).

Other analytic units require complex identification transformations, and studies of these are now in their infancy. For example, a topic of increasing importance is the detection and explanation of horizontal artifact patterns on occupation surfaces. Most investigators have assumed tacitly that they are dealing with primary refuse in these situations (e.g., Goodyear 1974; Whallon 1973), but recent ethnarchaeological findings (Yellen 1974) suggest that occupation floor deposits are formed by more complex processes than merely primary refuse disposal. Research now should be undertaken to identify specific transformations for partitioning occupation floors into behaviorally meaningful analytic units that will allow the materials to be treated with appropriate statistics.

The Reid model is particularly well-adapted for use with computer-assisted analyses. This is so because the analytic units of the model are equated easily with the statistician’s “case,” and artifact type frequencies within the units readily become the variables. In Chapter 12, this model partially forms the basis of a reconstruction of chipped-stone artifacts related to activity sets, from secondary refuse deposits at the Joint Site.