SOCIAL COMPLEXITY AND THE ORIGINS OF AGRICULTURE:

A Complex-Systems Theory Of Culture

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By

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ABSTRACT

Archaeological research is typically conducted within a paradigm methodology. Within this type of methodology the researcher provides the context of investigation and interpretation. This situation produces subjective knowledge that is difficult to transfer to a broad based discipline, and this methodology produces unique interpretations, which are largely neither repeatable nor testable.

All sciences must contain the paradigm methodology, but a mature science will transcend the paradigm methodology by also engaging in research that is based on a theory methodology. The theory is the backbone of science, and it constitutes the basis for the distinctive objective nature of scientific knowledge. Theory provides the conceptually objective context within which individual researchers produce objective knowledge that is repeatable and testable, and that, to a large extent, is comparable across a broad spectrum of research within a discipline. Many archaeologists have advocated a scientific approach to archaeological research, but this idealistic goal has remained elusive.

I suggest that it is possible to construct a general theory of culture that explains cultural phenomena in conceptually objective terms. My research constitutes an attempt to synthesise a general theory of culture that is based on Implicit Learning Theory and Dynamical Systems Theory. The resultant theory (the Complex-Systems Theory of Culture [CSTC]) is explored and explained by engaging the archaeological data that is at the focus of the origins of agriculture in the Near East.

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The University of Liverpool deserves mention for continuing a tradition of broad academic endeavours, which allows unique scholars to fulfil their research potential.

And finally, the external examiner must be acknowledged. The final form and content of this thesis is, in large part, attributable to his efforts.

DEDICATION

This research is dedicated to all of those people who thought I was interesting, insightful, or just crazy, but listened to what I was trying to say. Thank you all, especially Dale and Nancy.

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INTRODUCTION

CHAPTER 1

INTRODUCTION

The fundamental purpose of this research is to synthesise a general theory of culture, which can explain cultural phenomena and cultural evolution. Within the context of this research culture will be presented in terms of the complex patterns of behaviour and material products that are identified with groups of people. The universal mechanism of cultural systems is presented in terms of information flow and accumulation, which is inherent to the learning process. Once the theory is sufficiently described it will then be used to investigate and interpret archaeological data. This task should provide concrete examples of the function and explanation of cultural phenomena that is inherent to the theory. This task should also demonstrate some of the advantages of theory-based research over paradigm-based research.

This research is fundamentally a theoretical project. The motivation for this research arose from a deep personal dissatisfaction with anthropological theory, which resulted in a desire to discover or construct a scientific theory that explains cultural phenomena. At the beginning of this research project I felt that Implicit Learning Theory could be combined with Dynamical Systems Theory in an attempt to synthesise a theory of culture. Under the guidance of my supervisors I took on the task of applying the anticipated theory to the archaeological data of the origins of agriculture in the Near East. Roughly this consisted of two large tasks. The first task was to synthesise a general theory of culture. The second was the application of the theory to archaeological data to demonstrate how the theory works and to suggest how it can be used to improve archaeological research.

One of the fundamental assumptions of this research is that Archaeological enquiry can be a science, and that the sign of a mature science, such as physics, is the quality of the body of theory that is used to direct the research. It is also my belief that an adequate general theory of culture can be used to unify all Anthropological research. This is an ambitious undertaking (especially for a three year research project), and this research must be founded on explicit descriptions of science, theory, paradigm, and their functions as a unit (see Chapter 2).

1.1 SUMMARY OF TOPICS

This first chapter is an introduction to and a summary of my research. It contains an overview of what my research entails, the context it fits into, what I am doing, how I am proceeding, my aims, methods, and what I hope to accomplish.

Chapter 2 provides the scientific context for my research. When I became a student of anthropology in 1990 I quickly became impressed by the virtual void of cultural theory in the field. This may be a surprising statement because most people see anthropology as one of those fields of research that is inundated by countless theoretical perspectives. My statement is based on a perceived distinction between 'theory' and 'paradigm'. This distinction classifies virtually all of what typically passes as anthropological theory as *paradigms*. This distinction will be explained in detail in Chapter 2, but a brief description of the distinction will be offered here.

In my view a paradigm constitutes knowledge that can be in a form ranging from a nebulous intuitive belief to a formal and explicit model. Paradigms constitute knowledge in the form of descriptions or definitions of phenomena, which in their most explicit form represent **arguments** about phenomena. Because the form of a paradigm is specified by the researcher paradigms are completely subjective at the conceptual level. On the other hand, theories constitute knowledge in the form of an explicit **explanation** of a phenomenon, which transcends the subjective beliefs of the paradigm by stating the inherent mechanisms that produce the phenomenon. Theories are offered as explanations of phenomena in terms of the inherent functioning of the phenomena, and this is how scientific knowledge can obtain a level of objectivity that has never been reached in any other human endeavour. Scientific knowledge in its ideal state is an objective explanation of a phenomenon that is constructed on underlying subjective knowledge, and, therefore, scientific knowledge is never completely objective. The first task of my research is to synthesise a general theory of culture that meets the minimum requirement of a scientific theory as discussed in Chapter 2.

The second half of Chapter 2 provides some examples of the use of theory in anthropological research. These examples are intended to demonstrate that *anthropological theory* is actually a set of paradigms, and they demonstrate how paradigms can be distinguished from theories. The last section of Chapter 2 demonstrates why Binford's methodology for constructing theory can only produce paradigms.

Chapter 3 is a brief review of General Systems Theory, how it has been applied to archaeological research, some of the reasons why it has failed to produce a lasting influence in archaeological circles, and why it has virtually been abandoned as an archaeological tool. This review is fundamentally an aspect of the context building for my research, and it is necessary due to the fundamental part Dynamical Systems Theory plays within the theory of culture that I have produced.

Chapter 4 constitutes a discussion of culture concepts and my synthesised theory of culture, which is referred to as the *Complex-Systems Theory Of Culture*. It is based on Implicit Learning Theory, which has been developed within the field of experimental psychology, and Dynamical Systems Theory, which has been developed largely from research into fluid dynamics. ILT is suggested as a representation of a fundamental and universal aspect of human behaviour, from which all human behaviour can be demonstrated. Due to the vast capacity for learning that humans display a second assumption is that they can be described as complex systems. DST represents an explanation of complex systems that allows a profound understanding of the universal human condition. From this perspective *culture* is presented as the observed complex patterns of behaviour and material products that are the result of the information flow that is inherent to the process of learning.

Chapter 5 reviews some of the very few attempts to employ DST in archaeological research. This review is important because it demonstrates that DST has only been used as part of a paradigm-based methodology in archaeological research until now.

Chapter 6 is devoted to a summary review of the archaeology of the Near East. The time reference of the surveyed literature ranges from the Upper Palaeolithic through the middle of the PPNB. It is beyond the scope of this research to present a comprehensive survey of this literature. Many areas have only briefly been reviewed and some have been entirely missed out. The aim of this review was to provide a general context for the research that has been undertaken within the parameters of the survey, and always with an eye to that published material that is useful for the application of my theory.

Chapter 7 represents an attempt to explain the Complex-Systems Theory Of Culture in more detail, and to show some examples of how it can be used to analyse archaeological data. One of the issues that will be engaged is Social Complexity in the Natufian. This is important because several researchers have suggested that the Natufian represents an example of complex hierarchical social organisation.

Chapter 8 attempts to use the Complex-Systems Theory Of Culture to compare the Natufian social organisation to some relevant data from the PPNA and PPNB. These comparisons represent a clear demonstration that some of the complexity of social organisation that is not evident in the Natufian is beginning to appear in the PPN.

1.2 AIMS AND OBJECTIVES

1.2.01 Aims

1) Produce a general theory of culture and cultural evolution that encompasses as many of the more powerful paradigms of culture that are generally employed at the present time.

- Address issues such as the paradox of making and being made by culture.
- Address the paradox of universalism vs. particularism.
- Get away from the deterministic ideas attached to culture.
- Culture is process dependent and not structure dependent (i.e. culture as a process and not an object).
- The complexity of culture vs. the simplicity of cultural processes.
- To introduce a bottom-up approach to culture instead of the top-down approach that is virtually the exclusive methodology of the social sciences.
- The top-down paradigms of the social sciences are characterised by the arbitrary distinctions and categories that are employed to give them substance [cf. "individuation" and "totalisation" of Heywood (1993)]
- Moving beyond analogy and metaphor.

2) Describe the theory.

3) Use data to provide examples of how the theory works, and how it performs as a valid research tool.

1.2.02 Objectives

My research has two main objectives; first, I will present the synthesis of a general theory of culture, then I will demonstrate some of the applications of such a theory to archaeological research using existing data. The presentation of this theory will be at a very conceptual level. This is due in part to the length of time needed to generate a formal theory. It is also due to the lack of good mathematical models for dealing with complex theories that are comprised of many simultaneously interacting parameters. The final reason for keeping this theory at a conceptual level at this time is my personal lack of expertise with non-linear mathematics that are available at this time.

My second objective involves the development of specific aspects of the general theory to enable it to engage the existing data. This is possible because the information paradigm has been a part of archaeological research from its inception.

1.3 METHODOLOGY

There are three parts to the methodology employed here. First, the synthesis of a general theory of culture is based on the assumption that synthesising existing theories produces a valid new theory as long as no aspect of the original theories is violated in the process. Complex-Systems Theory of Culture is the result of a synthesis of Implicit Learning Theory and Dynamical Systems Theory, and the internal structure and organisation of both of these theories is preserved in the synthesised theory so CSTC should be valid.

The second aspect of the methodology of this research involves the development of specific propositions that pertain to cultural phenomena. This involves using the general theory to generate specific propositions that can be used to engage specific data. This part of the methodology was complicated by the fact that archaeological data is recorded and published using a multitude of paradigmatic perspectives. This means that CSTC must be used to specify how to interact with the existing data that has been extracted from the archaeological record.

The third aspect of the methodology involves using CSTC to actually engage the archaeological data in a meaningful way. If the first two aspects of methodology are achieved and the theory is a non-trivial explanation of cultural phenomena then using CSTC to reconstruct and analyse archaeological data should produce non-trivial results.

CHAPTER 2

A SCIENTIFIC CONTEXT FOR ARCHAEOLOGY

CHAPTER 2

A SCIENTIFIC CONTEXT FOR ARCHAEOLOGY

This research may seem to engage familiar concepts, such as *culture*, *archaeology*, *science*, and *theory*, but this thesis presents some unique challenges to the reader because it engages these terms from a unique perspective. First, the thesis was conceived and executed within the Archaeology Department of The University of Liverpool, but it is **not** a *traditional archaeological* thesis. In other words, if the reader tries to place this thesis within a framework of standard archaeological perspectives the result will be confusion, misunderstanding, and arguments that are at cross-purposes. Second, this thesis is fundamentally a theoretical endeavour, and it represents a significant departure from how many people typically conceptualise *science* and *theory*. The magnitude of this departure is the rationale behind presenting an entire chapter that is devoted to explaining this unconventional perspective of *science* and *theory*. Third, each chapter will present new concepts, and these concepts will be imbedded in the understanding of the unique concepts presented in previous chapters. For example, my concept of theory will be used consistently throughout the thesis; therefore it is critical to later arguments and examples that the reader gains an adequate familiarity with my perspective. If the reader brings expectations to this thesis that are based on more conventional concepts of theory, then it is quite likely that the thesis will seem incomprehensible. Fourth, although much of the discussion revolves around the concepts of theory and science, this thesis does not engage the long running debate about archaeology as a science. For example, the question about whether archaeology is or is not a science and the question as to whether archaeology should or should not be a science are irrelevant to this thesis. My research has been conducted within the context that archaeology, in fact all of the fields of Anthropology, can be a science in just the same way that physics is a science. What are presented here are arguments as to what constitutes science and how archaeological research could be scientific in a sense of the term that is equivalent to how it is used to describe physics. The traditional arguments about anthropology and science do not engage the rather unique perspective presented within this research, therefore any comprehensive review of those arguments would be tangential to this research.

This approach compels me to situate my research in a more explicit view of theory than would be necessary for more traditional empirically based projects. My concept of theory is based on the belief that scientific knowledge is qualitatively distinct from other forms of knowledge because of its public and objective attributes. This view of science will be presented in relatively broad and general terms. It is important to be aware that this is not meant to be a statement of how science is actually conducted, or how science should be conducted. It is simply an explicit description of the model of science within which my research has been conceived and conducted.

My view of science is based on the belief that science strives to produce knowledge that is public and objective to a degree that qualitatively transcends the knowledge produced by all other human endeavours. This view is based on the distinction that I establish between a *paradigm* (which only represents knowledge) and a *theory* (which represents both knowledge and understanding). Theory transcends paradigms by providing an explanation that produces understanding of a phenomenon because the underlying mechanisms that produce the phenomenon are explicitly stated. Theory, as an explanation, is a heuristic device that allows science to produce public and objective knowledge, which distinguishes scientific knowledge from all other forms of knowledge.

Within the discussion of the distinction between paradigms and theory I present my view of the process of science, and I describe how paradigms and theory fit together in that process. Theory and the scientific process are relatively easy to accept for deterministic relationships, such as Newtonian mechanics, but I expand my discussion to demonstrate that my views of theory and science are also valid for non-deterministic relationships, such as biological evolution. This view of science should also hold true for the non-deterministic relationships that are investigated by anthropological research.

The concepts that typically pass for theory within the field of anthropology do not meet the basic criteria for my view of theory (anthropological and archaeological theory represent subjective arguments, not conceptually objective explanations). I discuss Marxist concepts to demonstrate why *anthropological theory* has not transcended the form of a paradigm. After my discussion of the Marxist paradigm I demonstrate that Binford's concept of archaeological science is compatible with the view I present, but Binford's methodology for constructing theory fails to produce the type of theory that is necessary for the concept of science that is stated as his goal. I suggest that the failure of Binford's methodology for achieving a science of archaeology can be attributed to the philosophical model that Binford chose. I proceed to demonstrate why Binford's chosen model of science fails to produce the public and objective knowledge that is stated in his concept of science.

2.1 SCIENCE

Nagel (1961) presents a very cogent perspective of how humans have been acquiring vast amounts of reliable knowledge for a very long time before science became a part of our modern existence. In fact the vast majority of modern humans attain virtually all of their valuable and reliable knowledge without the benefit of scientific training (Nagel, 1961). This fact leads Nagel to ask:

> "If so much in the way of knowledge can be achieved by the shrewd exercise of native gifts and "common-sense" methods, what special excellence do the sciences possess, and what do their elaborate intellectual and physical tools contribute to the acquisition of knowledge?" (Nagel, 1961: 1)

In his exploration of this question Nagel discounts several concepts of science. For example, a common usage of the word "science" is that it implies the possession of the final truth (Nagel, 1961). This notion would render the term science virtually unusable because few if any areas of research possess infallible guaranties of truth (Nagel, 1961). Another usage that Nagel discounts is that scientific knowledge is merely organised or classified common-sense knowledge. Nagel offers the view that what makes science distinct from common sense is that science offers highly organised and systematic *explanations* of the knowledge that is attained. For example, common sense knowledge tells us that all objects fall, but science explains why all objects fall. This is a common view of the distinction between science and other forms of knowledge, but I think it is not adequate or at least misses the mark slightly. Science does strive to explain phenomena in terms of principles that formulate relationships between items in wide areas of fact, and this does distinguish science from common-sense knowledge. Yet there is a more important, if more subtle, distinction between scientific knowledge and all other forms of knowledge.

Some researchers attempt to circumvent the problem of defining science by simply offering a list of the *ideals* of science. One such characterisation is offered by Kelley and Hanen:

> "…the traditional marks of science – replicability, mathematical precision, objectivity, and the like…" (Kelley and Hanen, 1988: 6)

My experience has taught me that trying to proceed without any definitions is a futile exercise that produces confusion. Most of the definitions presented here will be "working" and not "strict" definitions. This methodology means that the definitions offered will vary widely in form, detail, and level of explicit expression of the concepts engaged. For a definition of "science" I will begin with Richter's (1973) general description:

> "Science is to be provisionally defined here as the process, or the group of inter-related processes, through which we have acquired our modern, and ever-changing, knowledge of the natural world..." (Richter, 1973: 1)

This definition makes explicit two aspects of scientific activity that are very important features of my model of science. First, science is conceived as a *process*. It is a continuing activity that changes as the tasks, tools, concepts and other conditions of scientists' lives change. Second, science produces *knowledge* (see also Morgan, 1973; Kelley and Hanen, 1988; Binford, 1989; Porter, 1990; and Lipton, 1991and 1995). This view stands in stark contrast to other concepts of science that state that the purpose of science is to produce *truth*, *reality*, *explanation*, or some progressing approximation of these (Toulmin, 1961 [from Arnold, 1985]). A fundamental tenet of Implicit Learning Theory is the fact that all human endeavours produce knowledge (Reber, 1993), but for science to be distinct from other endeavours it must produce knowledge that is sufficiently different from other forms of knowledge to warrant such a distinction.

2.1.01 Scientific Knowledge

The traditional views of science have been undermined by scepticism about the validity of our knowledge. Many traditional scientists thought that they were discovering the "truth" or the "reality" of nature, but a number of noted philosophers have argued that truth and reality are not within the scope of human knowledge (i.e. Hume, Popper, Nagel, and Quine). Humans can only know sensory stimuli and the meanings we assign to these sensations. Truth and reality may well be out there, but humans only have access to subjective experiences. This sceptical view is attributed to Hume by Lindh (1993). Hume's "inductive problem" is based on Hume's realisation that Nature transcends human experience (Lindh, 1993). To put it another way, Nature is infinite and human experience is finite, therefore, humans can never claim to know anything about Nature with any degree of certainty. Faced with this daunting conclusion many scientists have changed their stated objective from "truth" to "explanation". But this is just as problematic as was the goal of discovering "truth". The consensus opinion is that an explanation can never be verified, and the question of what constitutes an "explanation" has never been satisfactorily answered (Lipton, 1991: 23). This may be due to the fact that the quest for a satisfactory idea of "explanation" has also been crippled by the stipulation that it must represent "truth" or "reality".

While the arguments about "truth", "reality", "explanation", and a large number of other possibilities have ground to a standstill, scientists have been busy producing knowledge. It is my contention that "knowledge" is what science is fundamentally engaged in producing. On the other hand, all human endeavours produce knowledge. If science is to stand for something distinct (and I think it does) then scientific knowledge must be unique in some significant way. Scientists have traditionally made two claims for the knowledge they produce; it is public and it is objective. The public nature of science has traditionally been characterised as a fundamental aspect of the methodology of scientists that states that they should all share their knowledge with each other, and their results should be amenable to replication and verification by others. Scientific knowledge was thought to be objective because it was more than a description of the subjective experiences of a researcher (Popper, 1959). The ideal of public and objective knowledge is what distinguishes science from other endeavours, but the old concepts of what constitutes "public" and "objective" have been strenuously criticised.

The 'public' aspect of scientific knowledge has received much less attention in recent discussions, but it is just as important as the 'objective' aspect of scientific knowledge. In Cohen's (1985) discussion of scientific revolutions he touches on the 'public' feature of science as it pertains to the publishing of new work or new ideas, which he states is what takes a scientific revolution from the private phase to the public phase. In this context scientific knowledge is 'public' because it is submitted to peer review and is relatively easy to access by scholars and others. I suggest that scientific knowledge is fundamentally 'public' in a much more subtle and important way. Scientists reduce large amounts of 'data', 'observations', or 'information' to very concise causal or relational propositions that can be passed on to other researchers and students with only a small fraction of the original data used as examples (see Nagel, 1961). For example, once Newton had worked out his celestial mechanics (based on inertia and universal gravitation) almost anyone could learn and apply the causal/relational concept without having to go through the process that Newton did. In other words you can understand the results of Newton's work and take that work and put it to use for your own purposes without having to go through all of Newton's experiences or engage all of the data that Newton did. This stands in stark contrast to all other human endeavours. For example, music, the fine arts, and historical research produce 'personal' knowledge that cannot be substantially transferred to another person. You can appreciate the music of the soloist, the masterpiece of art, or the reconstruction of the past by a great historian, but you cannot gain access to their knowledge and produce your own work without reproducing, in a very substantial way, their experiences. The example provided by Newton's success is even more dramatic when you consider that within the span of his life he was able to produce a synthesis that encompassed the work of hundreds of scholars, which engaged data that were collected within a time span of more than a thousand years, and it brought together a multitude of previously distinct phenomena by demonstrating that they all shared a common underlying mechanism. Not only did his synthesis provide a tool for gaining more knowledge, which was relatively easy to transfer to a large number of people, but this tool gives virtually everyone access to all of the observational knowledge that originally required many life times to accumulate.

Scientists have often claimed that the knowledge they produce is objective. It can be demonstrated that this is not always the case, but I suggest that objective knowledge is an ideal that scientists typically strive toward. The 'objective' nature of scientific knowledge has been adequately discussed in many other forums so I will restrict my comments. Within my paradigm of science it is understood that all human knowledge is fundamentally subjective because it is ultimately based on human experience (Popper, 1959 and 1983; Nagel, 1961). It is also understood that scientific knowledge is and has been acquired within an ideal of employing methodologies to produce knowledge that is as objective as is humanly possible. There are two fundamental ways to increase the objective content of our knowledge. (1) We can make observations that are based on external (universally agreed upon) standards, and (2) we can construct frames of reference that are not immediately (proximally) dependant on the human perspective. The first form of objectivity is relatively easy to achieve, and it is often the subject of discussion when objectivity is described (i.e. Binford, 1989). The second form of objectivity is much more difficult to achieve and is substantially the ideal of objectivity to which scientists have aspired. Conceptual objectivity refers to a framework where statements about a phenomenon are formulated in non-subjective terms. Conceptual objectivity constitutes my fundamental distinction between "theory" and "paradigm", and I will return to it later in the discussion of science.

This perspective presents scientific knowledge as fundamentally distinct from other forms of human knowledge. Ideally scientific knowledge achieves conceptual objectivity, which is distinct from the thoroughly subjective nature of other forms of knowledge, by employing theories that are explanations of phenomena. Scientific theories should **not** be thought of as *true* or *correct,* they are heuristic devices that are constructed in terms of the perceived inherent mechanisms that seem to produce the observable effects of the phenomenon that is being examined. On the other hand, all other forms of knowledge are conceptually subjective because they are arguments about phenomena that are presented in the subjective terms of the observer – not in terms of the phenomenon. It is this conceptually objective context of a theory, which is expressed in observationally neutral terms, that allows scientific knowledge to achieve a degree of public availability that is qualitatively distinct from all other forms of knowledge.

2.1.02 The Scientific Process

To understand my model of science it is necessary to discuss the process of science in general terms. Figure 2.01 is a very simplistic schematic of the phases of the scientific process. My description of the scientific process starts with an observational/descriptive phase. In this phase large amounts of data or information are accumulated and described in a number of different ways. All of the data/information that is collected in this phase is based on our largely implicit beliefs, but some of our beliefs may be stated explicitly. These implicit and explicit beliefs are the subjective paradigms that are the foundation of all knowledge. The second phase represents the formulation of a theory that is proposed to 'explain' the observations, descriptions, or some critical sub-group of these. Theory formulation usually involves some nebulous but often monumental effort of creative intuition, which has caused it to remain an enigmatic aspect of the scientific process. The third phase of science consists of the use of the theory to conduct either new research or to continue extant research in some altered form that is specific to the new theory. This process results in the collection of more data, observations, and/or descriptions. This new body of data is often used (by at least some researchers) to explore the functional efficacy of the theory, and can lead to total rejection or significant modification of the theory.

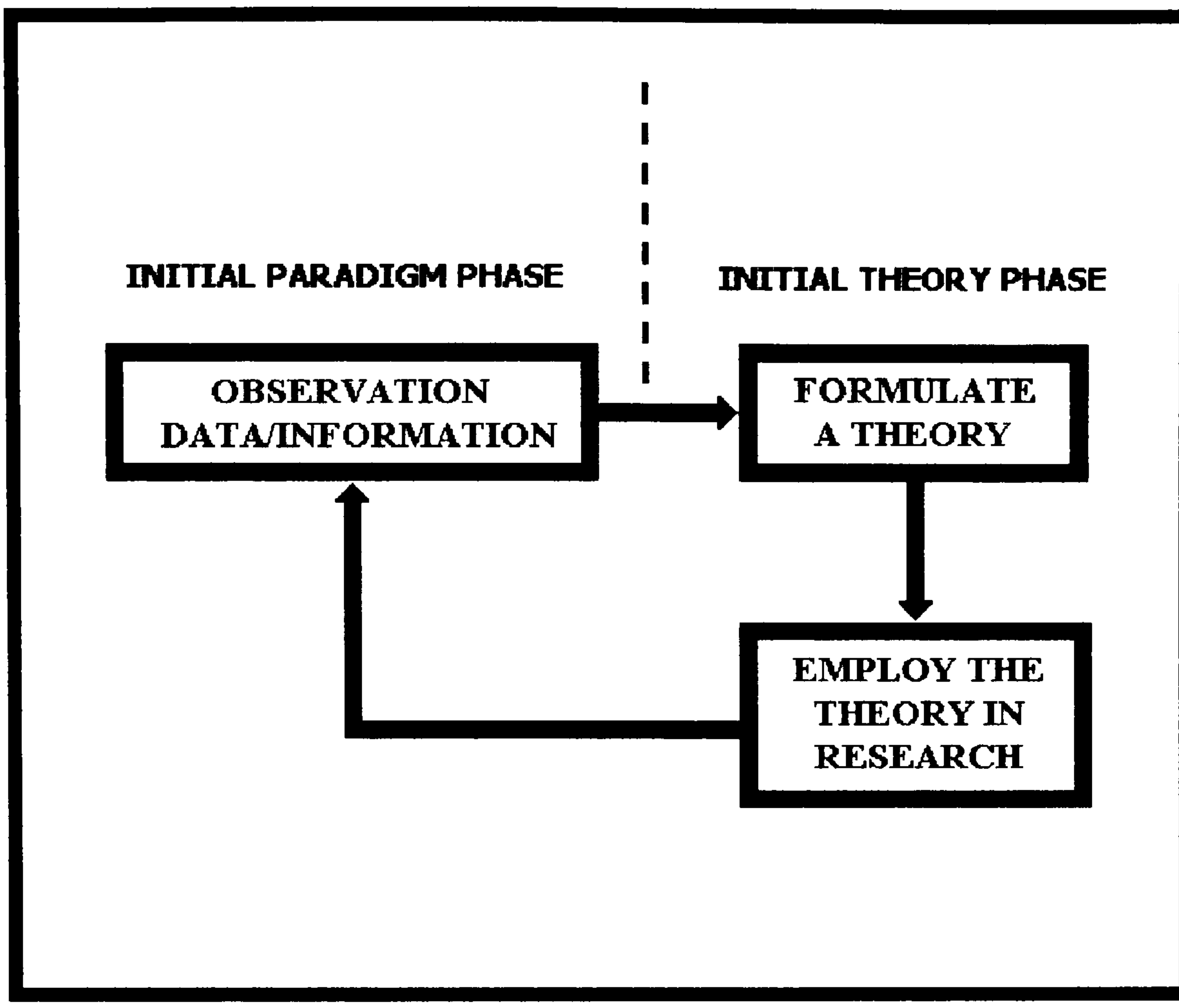

FIGURE 2.01 – The scientific process.

If the theory is found to be adequate, this period of using the theory to conduct research will often result in the production of ancillary theories that are special purpose and serve to extend and clarify the original theory. At this point we can envision science as a reiterative process where each iteration produces more data, hypotheses, and adjustments to the theory, which is needed to encompass the ever-growing mass of information and knowledge that is being generated. This reiterative phase of science is analogous to Kuhn's (1962) *normal science*. Ideally the knowledge produced in the theory phase will be public and objective, and this will distinguish it from the knowledge produced in the paradigm phase. This aspect of science will be discussed explicitly as part of the discussion of paradigms and theories.

To summarise, science is engaged in discovering knowledge that differs qualitatively from all other knowledge in that in its ideal form it is objective and public. The process of science described above is a very simplistic sketch, and it leaves vast amounts of room between the initial observations and the formulation of a theory that will accommodate any number of specific methodologies. Each phase is approached in a variety of specific ways depending on the current school of thought dominating a particular field of scientific research. This process of science does, on the other hand, establish a heuristic that can be used to investigate paradigms and theories at a more explicit level of discussion. The following discussion will also serve to add more detail to these phases of the scientific process as it applies to the concept of science employed in my research.

2.2 THE PARADIGM CONCEPT

I will discuss paradigms and theories from the perspective of what constitutes "knowledge" and "understanding". Within the field of philosophy this distinction is typically stated as 'knowledge is *the belief that the case is*' and 'understanding is a belief about *why the case is*' (Lipton, 1991). For example, this distinction is the difference between believing that "the earth is a sphere" and believing that "the earth is a sphere because the gravitational forces of matter tend to pull all large masses into a spherical shape". This example provides the basis for two clear distinctions between paradigms and theories. First, a paradigm is largely about knowledge and a theory is primarily focused on understanding. Second, paradigms are largely implicit, and theories are always explicit. In other words, paradigms represent implicit beliefs and theories represent explicit explanations of observed phenomena. All research (and knowledge) begins with paradigms, but science is distinguished by the ideal of transcending paradigmatic knowledge by transforming it into theoretical knowledge.

In discussing paradigms and theories I will employ the example that is often referred to as the "Copernican Revolution" (Cohen, 1985). From a historical perspective this example can be seen as the transition from the paradigm phase of research (characterised by competition between several models of planetary motion) to the theory phase of research (which is dominated by Newton's planetary mechanics). This example of the scientific process was chosen because it is one of the clearest and most powerful examples of the transition from the paradigm phase to the theory phase of scientific research. As the theory concept is developed I will also explore two other examples (Darwin's theory and the Marxist paradigm) before continuing on to an exploration of these concepts within the field of archaeology.

2.2.01 The Paradigm

To understand the roles of paradigms and theories they need to be defined, but like the concept of "science" they are not objects so definitions will be difficult. Never-the-less, this is time well spent. Kuhn (1962) provides a loose definition for paradigm, but as many authors (including Kuhn) have pointed out the definition is too vague. Also, Kuhn's examples employ 'paradigm' to refer to various concepts (some of which seem to be contradictory) so that no clear concept of 'paradigm' can be inferred from his text. In the absence of an existing definition of "paradigm" that is both adequately clear and functionally relevant to my view of the scientific process I will provide a working definition.

In his later works Kuhn (1970) attempted to clarify the ambiguity of the paradigm concept. He presents the idea that there are two types of paradigms, and the first is understood in this way:

> "... it stands for the entire constellation of beliefs, values, techniques, and so on shared by the members of a given community." (Kuhn, 1970: 175)

This is the conceptual basis for the general definition that I will use for the term "paradigm". It presents paradigms as having several features. First, the inclusion of "beliefs, values, and techniques" indicates that paradigms represent a broad spectrum of implicit and explicit conceptual frames. Second, Kuhn presents it as a constellation, which indicates that a paradigm incorporates a number of concepts that comprise a whole or at least tend to fit together in a loosely recognisable pattern. Third, it suggests that there will be some differences between the constellation of beliefs held by an individual and those shared by the members of a community. Fourth, paradigms are completely subjective because they are based directly on human experience. I will add a fifth aspect; a paradigm can be a very singular concept or it can be any number of concepts that appear to represent a constellation of beliefs. In other words, paradigm stands for the largely implicit conceptual frames that all people use to observe and behave in the world.

Kuhn's (1970) second type of 'paradigm' is described as:

> "... the sort of paradigm that identifies challenging puzzles, supplies clues to their solution, and guarantees that the truly clever practitioner will succeed." (Kuhn, 1970: 179)

This description is very close to my concept of a "theory", which I will develop after my discussion of paradigms. I agree that paradigms are views or beliefs (as part of Kuhn's definition tells us), but that they differ in very important and substantial ways from scientific theories. It is this functional difference and the functional relationships of paradigms and theories within the scientific process that I will explore in order to provide an understanding (incomplete as it may be) of these two important parts of science.

My definition is:

> Paradigms are the subjective ideas, beliefs, and methodologies that form the conceptual frames within which humans learn and act.

Paradigms have certain distinct features that not only help to distinguish them from theories, but also provide insight to their functional role in the scientific process. The features of paradigms that will be discussed here are:

1) Paradigms are largely implicit – only a few paradigms can be stated explicitly (some of these may be rendered into formal models)
2) Paradigms are totally subjective at a conceptual level
3) Paradigms are largely ambiguous
4) Paradigms tend to affirm the consequent (because they are typically based on circular arguments)
5) Paradigms appeal to common sense
6) Paradigms typically employ arbitrary research categories
7) Paradigms typically employ a Top-Down methodology
8) Paradigms are infinitely accommodating
9) Paradigms are mutually equivalent
10) Paradigms are impervious to evaluation by observational data
11) Paradigms cannot direct research (paradigms do not specify a context)
12) Paradigms do not entail data
13) Paradigms produce personal knowledge

A paradigm can be either an implicit or an explicit belief. In its most explicit form a paradigm is a subjective argument that is presented in terms of the observers experiences, which are not observationally neutral.

2.3 THE THEORY CONCEPT

I have expressed the view that science is distinct from other endeavours because it strives to achieve an ideal of *public* and *objective* knowledge that is qualitatively distinct from the knowledge that is acquired by other endeavours (which can be *public* and *objective* to a lesser degree). The *scientific theory* (here after "theory" shall mean "scientific theory") is a heuristic device that allows the process of science to pursue this ideal of scientific knowledge. My concept of "theory" is based on the distinction between "knowledge" and "understanding" that is expressed by some philosophers. According to Lipton (1991, 1995) knowledge is "the belief that the case is" and understanding is "a belief about *why* the case is". For example, the fact that the sun rises in the east is *knowledge*, but knowing that the sun rises in the east because of the rotation of the planet is *understanding*. Paradigms only represent *knowledge*, but a theory represents both *knowledge* and *understanding* through its appeal to an explanation that is potentially subject to empirical tests. This view is distinct from more traditional concepts of "theory", which are often explicitly linked to a narrowly prescriptive view of what constitutes science. This narrowly prescriptive view of science tends to create a situation where there is much arguing about what is the "correct" methodology and definition of theory that must be employed to produce "true" science (Hodge and Cantor, 1990; Lipton, 1991; Dark, 1995). I suggest that theory represents a heuristic device that is used to produce knowledge that has an objective and public content that is qualitatively distinct from the knowledge that is produced within the context of a paradigm.

My broader use of the term *theory* means that the concept encompasses a number of forms of *theory*. For example, Newton's theory of motion states that all objects move due to the forces that act on them. This is a *conceptual* form of theory, and it represents a functionally valid form of scientific theory. On the other hand, Newton was capable of producing a mathematically operational form of his theory, which is typically referred to as Newtonian Mechanics. The fact that Newton's Mechanics is a form of theory that is rendered in a formal and explicit system does not make it any more *scientific* or *valid* than the conceptual form. Newton's Mechanics may have more practical utility than the conceptual form of his theory, but it also has more assumptions than the purely conceptual form. Also, theory can be expressed in a *deterministic* form, such Newton's theory, or in a *non-deterministic* form, such as Darwin's theory. Theories that are expressed in deterministic terms are no more *valid* or *scientific* than non-deterministic theories. Deterministic theories may seem to have greater utility for practical applications, but that is partly due to the fact that deterministic relationships are more obvious and straightforward.

The concept of theory presented here is that it is an attempt to provisionally explain a phenomenon (Lewontin, 1974; Willer and Willer, 1974; [from Dunnell, 1989]). My discussion will try to maintain a level of generality that includes all sciences and yet is prescriptive enough to make a distinction between 'theory' and 'paradigm' that is functional within scientific endeavours. The working definition employed here is:

> A theory is a provisional explanation of a phenomenon that consists of propositions that explicitly express the relationships between defined elements of the phenomenon in terms of the underlying mechanisms or processes that produce them.

Paradigms, even at their most explicit, are based directly on implicit beliefs. Theory, on the other hand, explicitly states the relationship between the phenomenon at one level and the explicit beliefs about the mechanisms that produce the phenomenon, which are situated at a lower level. The following list of characteristics may help to clarify what a theory is:

1) Theory is explicit
2) Theory focuses on explanation
3) Theory attains a level of objectivity that is qualitatively distinct
4) Theory is rigorous
5) Theory is coherent
6) Theory can be used to direct research
7) Theory provides an operational expression of a paradigm
8) Theory is testable
9) Theory entails data
10) Theory produces public knowledge

A theory is an explicit and conceptually objective explanation of a phenomenon. The explanation presented is not meant to be a statement of truth or reality; it is only constructed as a heuristic device to facilitate research and the acquisition of knowledge and understanding. A theory can easily be distinguished from a paradigm because it presents a substantive (non-trivial) explanation of a phenomenon that is stated in observationally neutral terms. Paradigms, in their most explicit form, are subjective arguments about phenomena, which can be used to gain knowledge but not understanding.

2.3.01. Theory As Explanation

Explicit Paradigms represent knowledge (as opposed to understanding) in the form of stated beliefs about observed phenomena. That knowledge is expressed explicitly as descriptions, definitions, and interpretations of subjective experience. The explicit expressions of paradigmatic knowledge are based on implicit and subjective beliefs. Paradigms are not empirical explanations, but quite often a rationalisation or myth is offered as a part of the paradigm that seems to answer the "why" question. For example, Aristotle *explained* that the motion of objects was due to their proclivity to *seek* their natural place in the universe. Some paradigms are attributed with explanatory power because they can make claims to higher levels of generalisation. For example, a paradigm could *explain* that this crow is black because all crows are black. Neither of these types of *explanation* provides understanding, they simply restate the knowledge without adding any insight to the phenomenon.

The structure of a paradigm is such that explicit beliefs about the world of observational data (including formal models such as Galileo's Law) are based completely on implicit beliefs. In its most common form an explicit paradigm is simply a statement of a perceived regularity. This structure fundamentally represents the model provided by Galileo's Law. On the other hand, Newton's theory has a distinctly different form.

Newton's theory of planetary motion does not just describe, it also explains. A theory explains an observed phenomenon in terms of its underlying processes or mechanisms (the universal elements of all forms of the phenomenon). The underlying mechanisms are explicit beliefs about how the phenomenon functions, and these beliefs are based on implicit beliefs about everything. By offering a reasonable explanation of a phenomenon, theory transcends paradigms by providing understanding as well as knowledge. On the other hand explanation is not what science is about. Explanation in the form of a theory is a heuristic device for achieving public and objective knowledge, which is also empirically verifiable. This form of knowledge, which is qualitatively distinct from paradigmatic knowledge, is what science is about. This view of science will be explored using Newton's theory of motion.

Newton's theory takes the general conceptual form:

> The motion of any object is described as the sum of the magnitudes and trajectories of all forces acting on that object.

Newton's theory states that the motion of any object can be understood in terms of forces and the concept of inertia. The law of inertia states that the motion of an object must be the result of a force, and that once in motion the trajectory and magnitude of the motion will remain constant until altered by another force. Newton's theory provides a framework for investigating the motion of objects that is lacking in any paradigmatic perspective, such as Galileo's Law. Galileo's Law only describes the motion observed by the researcher (a subjective perspective). On the other hand, Newton's theory expresses a precise relationship between motion and the cause of motion – forces. This relationship specifies that data relevant to forces are what must be collected and investigated when engaged in any research that deals with the motion of objects. In contrast, Galileo's Law provides no insight into motion and how to investigate it because it is only a formal description of observational data. This example demonstrates that it is the element of explanation that fundamentally distinguishes theory from paradigm.

The first difficulty encountered in expressing "theory" as an explanation is the ambiguous nature of the concept of "explanation". Explanation can take many forms. Explanations have been formulated on a continuum that ranges from general to specific. An example of a very specific explanation is given by Hempel in the form of Semmelweis' work with "childbed fever" (Kelley and Hanen, 1988: 32). Semmelweis employed a classic methodology of research to demonstrate that childbed fever could be passed on to other children by close contact, but this explanation was specific to childbed fever and not suggested as a general principle of contagious disease. Explanation can also be anywhere on a continuum from the concrete to the hypothetical. Not all of these types of explanation will provide the desired results required by *scientific ideals*. For example, hypothetical explanations fail to provide the basis for the transition from the paradigm phase to the theory phase of science. Kepler used magnetism as the force for explaining the elliptical nature of planetary motion. This use of magnetism represents a hypothetical explanation because Kepler had no reason to posit magnetism as the planetary force (other than that it was the only force he was aware of). Kepler had no argument for linking the existence of magnetism to the motion of the planets. On the other hand, Newton hypothesised the existence of "gravity" based on a wealth of data provided by Galileo. Newton could link gravity to planets by simply suggesting that they were free-falling objects, and by incorporating Galileo's data he could link planetary motion to gravity. In other words, Newton had concrete reasons for believing that a force (gravity) existed, and that it was operating in celestial motion. Gravity, like magnetism, could be described through its observable effects, and gravity could be demonstrated to have universal and consistent effects, but magnetism does not display universal effects. On the other hand, Newton could not observe gravity directly, and he could not explain why it existed or how it functioned. The unknown elements of his explanation were relegated to a lower (more fundamental) level of discussion.

I solve the problem of "explanation" by stipulating that explanation must conform to a specific form to qualify as an element of a theory. Explanation must be in the form of underlying mechanisms that can be demonstrated to be reasonably concrete. Of course what constitutes "reasonable" is another problem, but at this time I will leave that up to the individual researcher to justify. On the other hand, the example provided by Kepler demonstrates that the formulation of a theory as an explanation allows it to be empirically evaluated and possibly rejected. On the other hand, paradigms, even in their most explicit form, cannot be falsified or rejected by the application of empirical data.

2.3.02 Theories Achieve Objectivity

A theory explicitly defines the elements of a phenomenon and states the relationships between elements in terms of the underlying mechanisms or processes that produce the phenomenon. In contrast a paradigm is a statement of apparent facts about the observed phenomenon. For example, Galileo's Law is an explicit and formal description of the phenomenon of falling objects. Through a series of ingenious experiments Galileo was able to formulate a mathematical description of the relationships between the duration, distance, and velocity of a falling object. This allows anyone to calculate how far an object has fallen (or how fast it is falling) from the amount of time it has fallen. These relationships are deterministic so it is possible to calculate all of the aspects of a falling object given its starting condition and any one of its subsequent conditions. Some people might suggest that this represents public and objective knowledge, which is empirically verifiable. I would concede that this is a valid perspective, but that the nature of paradigmatic knowledge is qualitatively distinct from that of theory based knowledge. A discussion of Newton's theory of motion should demonstrate the qualitative difference between paradigms and theories.

Newton developed his theory within the context of an era when many new paradigms were being formulated. Galileo's experiments with pendulums and falling objects provided a wealth of observational data expressed as a formal mathematical law. Kepler's mathematical analysis of the orbits of the planets (based on a wealth of accurate observations provided by Tycho Brahe) demonstrated the elliptical nature of the motion of the planets and that this is consistent with the nature of an object under the influence of a force. Descartes' formulation of the idea of inertia was based on his observations of colliding objects and his 'Cartesian' mathematics. Newton added to these ideas and this wealth of data through his own work on forces (centrifugal and centripetal) and his new mathematics (now referred to as calculus). This placed Newton in a position to formulate the hypothesis of universal gravitation. By proposing the force of "gravity" Newton's theory stated explicit relationships between all freely moving objects in terms of the underlying mechanisms that produce the observed motion. This is distinctly different from Aristotle's "explanation" that objects fall (or move) because they are seeking their "natural" place in the universe. Aristotle's view does not inform us what constitutes an objects natural place so it is an untestable statement. Within Aristotle's paradigm there is no explicit relationship between an object and its motion, and you would have to know where its *natural* place in the universe was to predict its motion. This leads to an unique solution for the movement of every object in the universe. This Aristotlean paradigm is probably the one that Galileo was working within when he did his work with falling objects, in fact it is a paradigm that we could work within even today because paradigms are inherently ambiguous. For example, Newton's theory could be seen as an operational way of specifying an object's natural place in the universe. This demonstrates how ambiguous and accommodating paradigms are, and this shows that they do not entail data so they cannot be evaluated or used to specify research, which is exactly what theory does.

Galileo observed that freely falling objects displayed consistent regularities, which he rendered into a formal mathematical system. He established that any object (that is not restricted by air resistance) would fall 16 feet in the first second after it was released. This is often characterised as a public and objective formulation of motion, but it is so to only a limited degree. There are at least three reasons why this knowledge is public to a limited degree. First, Galileo's Law only describes the motion of falling objects, which is only a tiny portion of all the motions an object can experience. Second, Galileo's Law is only valid at the surface of the earth (which is an extremely restricted number of all the falling objects in the universe). Finally, Galileo's Law varies depending on the altitude of the falling object. For example, a researcher in Tibet will achieve a slightly different formula for falling objects than one at sea level, and a researcher at the bottom of a very deep mine will produce slightly different results than either of the other two. Galileo's Law represents a description of a universal observational context that is shared by all humans. It does not represent a universal description of falling objects.

Galileo's Law achieves a limited degree of objectivity, which is qualitatively distinct from the conceptual objectivity achieved by a theory. *Instrumental objectivity* might be a valid description for Galileo's Law. This description denotes the fact that Galileo's Law achieves objectivity through the use of standard measurements of time, distance, velocity and mathematics that are not subjective attributes of a given researchers experience. In contrast, Newton's theory achieves conceptual objectivity because it changes the frame of reference from the subjective experience of the observer to the mechanisms that produce the observed phenomenon. When anyone drops an object what we all see is that it falls straight down towards the surface of the earth. Galileo's Law is a formal description of that subjective experience, and it allows us to calculate that in the first second the object will fall 16 feet (if its path is unobstructed). Newton's theory allows the same calculation as Galileo's Law, but because Newton's theory expresses motion from the perspective of the force causing the motion we can examine many aspects of the motion of an object instead of just the one available to direct observation.

Newton's theory explains that the object will fall 16 feet in the first second because of the force of gravity that is operating on it. This theory sets up a perspective where the reference is not the observer, but rather the force that produces the motion of the object, and it allows us to select any relevant reference to describe the motion of an object. For example, when Galileo drops an object from the top of a tower his formulation tells us that the object will fall 16 feet towards the earth in the first second. Newton's theory allows us to select a perspective other than the observer and state that the object will fall 16 feet but it will also move laterally (west to east) 1300 feet (due to the rotational velocity of the earth). This means that the object is not falling straight down (as our subjective experience tells us), but is actually falling diagonally because two forces have acted on the object. By selecting other forces as frames of reference we could state the motion of the object due to the orbital velocity of the earth, the rotational velocity of our galaxy, or the velocity of our galaxy within the cosmos. Galileo's Law is restricted to the motion of objects that are observationally available to the researcher, but Newton's theory allows us to describe motion from perspectives that are not observationally available to the researcher. In other words, within the context of Newton's theory the researcher is no longer the only perspective from which the motion of objects can be discussed, and this provides a conceptually objective perspective that is not found in paradigmatic knowledge. Galileo was aware of the "observational" problem, and he discussed it in *Revolutionibus Orbium Coelestium* (1543). Newton provided the solution that Galileo was unable to discover, but even Newton was apparently unaware that his formulation solved the "observational" problem of subjectivity.

Theories can attain a public and objective nature that is at a qualitative level that transcends that which can be attained for paradigmatic knowledge. A theory is significantly public because it subsumes a vast amount of information within an explanatory framework that is not limited to the unique particulars of an observer's subjective experience. Newton's theory can be used not only to discuss and explore the particular motion of objects that is described by Galileo's Law, but also all other forms of motion in the entire known universe. This shift in the frame of reference from the subjective experience of the observer to an explanation of the phenomenon in terms of its underlying functions is also responsible for the conceptual objectivity that is achieved by a theory. Newton's theory is conceptually objective because the focus of the theory is the force that produces the motion of an object. Galileo's Law is not conceptually objective because it is nothing more than a formal description of Galileo's subjective experience. In other words, the context of Galileo's Law is the observer, and without the observer there is no up, down, or fall because these are subjective observational terms that are the context of the observer's perspective. In contrast, the force of gravity acts as the defining aspect of the context of objects that move towards each other in Newton's theory, and no observer is required for the discussion of the motion of objects.

2.3.03 Theories Entail Data & Direct Research

Theory, in the form of explicit explanation, provides the fundamental framework for scientific research in its ideal condition. Theory provides the basis for specifying the data that is necessary to engage in research, to direct research, and to formulate new hypothesis. For example, Newton's theory specifies that gravity is the primary force responsible for the motion of all celestial objects, and this provided the insight that guided the research on comets that eventually lead to the demonstration that they also have elliptical orbits with the sun at one of the foci. Newton's theory was also used to generate a hypothetical explanation of tides, and it specified the data needed to link tides to the moon and sun. An even greater advance was the ability to predict unobserved events and to locate unknown objects (such as the planets beyond the orbit of Saturn).

Paradigms cannot be used to direct research as theories do. Galileo's Law simply describes a particular class of phenomena – the motion of objects that is characterised as free-fall. It cannot be used to direct research into other types of motion because it provides no insight into the type of data needed to investigate these other classes of phenomena. At best a paradigm suggests a view of a phenomenon, but it cannot provide the basis for understanding what is needed to direct research and specify a valid data type for research. There is a conceptual gulf between Galileo's Law (which describes the observer's subjective experience) and any theory that can explain that experience in an empirically testable way. Newton transcended that gulf when he envisioned Galileo's Law as a description of the force of gravity, and experimentally worked out the lateral velocity that is required for a falling object to become an orbiting object. By recasting Galileo's particular description as one of the many forces that can act on an object Newton produced an objective theory of motion.

Newton's theory represents the first time in human history that anyone had ever moved out of the *paradigm* phase of science into the *theory* phase of science. By employing his *gravitational* explanation Newton not only provided a means by which the earlier paradigms could be evaluated (all of which were discarded except the superficially compatible model presented by Copernicus), but also a means to draw together many other phenomena (such as the erratic motion of the moon, the motion of comets, and even tides). Only theories can specify the form of research and the types of data that constitute appropriate research, which Dunnell (1989: 36) states is a crucial priority for archaeological research.

2.3.04 Theories Are Not Truth Or Reality

Theories do not represent "truth" or "reality" for two reasons. First, theories do not generate intransitive (unchanging) knowledge. Theories shift and change forcing the knowledge engaged by them to change also. Theories are fundamentally based on implicit beliefs. Beliefs are produced from experience, and experience is too limited to produce certifiable knowledge that is "true" for all times and all places. This is often referred to as "Hume's problem of induction" (Popper, 1959). Although the functional level of a theory is explicit and objective it is based on underlying mechanisms (which are explicit and subjective), and these, in turn, are based on implicit beliefs. There is no definable or measurable "truth" content in a theory (in this respect theories are ultimately equivalent to paradigms).

Second, theories are not "true" representations of a phenomenon. All theories are *idealised abstractions* of observed phenomena. For example, Newton's theory expresses the orbital path of all objects as an ellipse with the mass that is being orbited at one of the foci of the ellipse. Precise observations demonstrate that no orbital trajectory describes a precise ellipse, and the mass that is being orbited is only approximately near one of the foci of the quasi-ellipse. Also, to calculate the motion of objects they must be represented as point masses that have no volume. This is far from a realistic representation of a planet or the sun.

The form of explanation that I have proposed as "scientific theory" has been mentioned by a number of philosophers, but to the best of my knowledge it has never been thoroughly explored. One possible reason that philosophers have not investigated this form of theory and explanation is that it leads to an infinite regression (Lipton, 1991; Friedman, 1974) and not "truth" or "reality". It is possible to envision how this model leads to an infinite regress by simply imagining that the explicit but subjective level occupied by the underlying mechanisms could be replaced with an explicit and objective theory that explains these mechanisms. The new structure would have two levels of explicit and objective explanation above a level of explicit and subjective belief, which is above the implicit and subjective level. This process could continue indefinitely, which would lead to an infinite regression. This demonstrates that my structure of theory does not represent reality, but also that scientists should not rely exclusively on the works of philosophers for their models of epistemology. The agenda of philosophers engaged in epistemology appears to be a guest for intransitive knowledge (truth or reality). Scientists appear to have a more pragmatic agenda. They seem to be engaged in producing public and objective knowledge that is empirically testable. These two agendas do not seem to be completely compatible, and they may even be contradictory (McMullin, 1990).

Theory as explicit propositions provides a number of advantages over paradigms. Theories are rigorous and coherent in that the elements of a theory are explicitly stated, must fit together, and by definition cannot be contradictory. Paradigms, on the other hand, are ambiguous, can be easily accommodated, and do not express an explanation. Adopting a theory may not allow researchers to make claims about reality, but many contradictory paradigms can be either eliminated or relegated to a lower conceptual level. For example, acceptance of Newton's theory forces us to reject the models offered by Ptolemy and Tycho because it demonstrated that 'gravity' has a relational quantity that is directly proportional to the mass of an object, and since the sun is the only object in the proximity of the planets that has sufficient mass it must be the object that all of the planets (and their attendant moons) orbit. On the other hand at the level of the concept of gravity, which is not a theory but rather a paradigm, theological concepts of creation and scientific conjecture can coexist even when it is thought that they are contradictory. It only requires a little bit of clever rationalisation to eliminate any points of contention between apparently contradictory paradigms. For example, in Newton's conceptual framework the motion of the planets is completely explicable from the perspective of forces, but, for Newton, gravity was an inexplicable divine creation. By placing these two seemingly incompatible beliefs on different levels of the structure, both scientific determinism and divine creation can coexist within the same framework. The juxtaposition of inherently ambiguous paradigms and explicit theories precludes the possibility that this framework constitutes *truth* or *reality*.

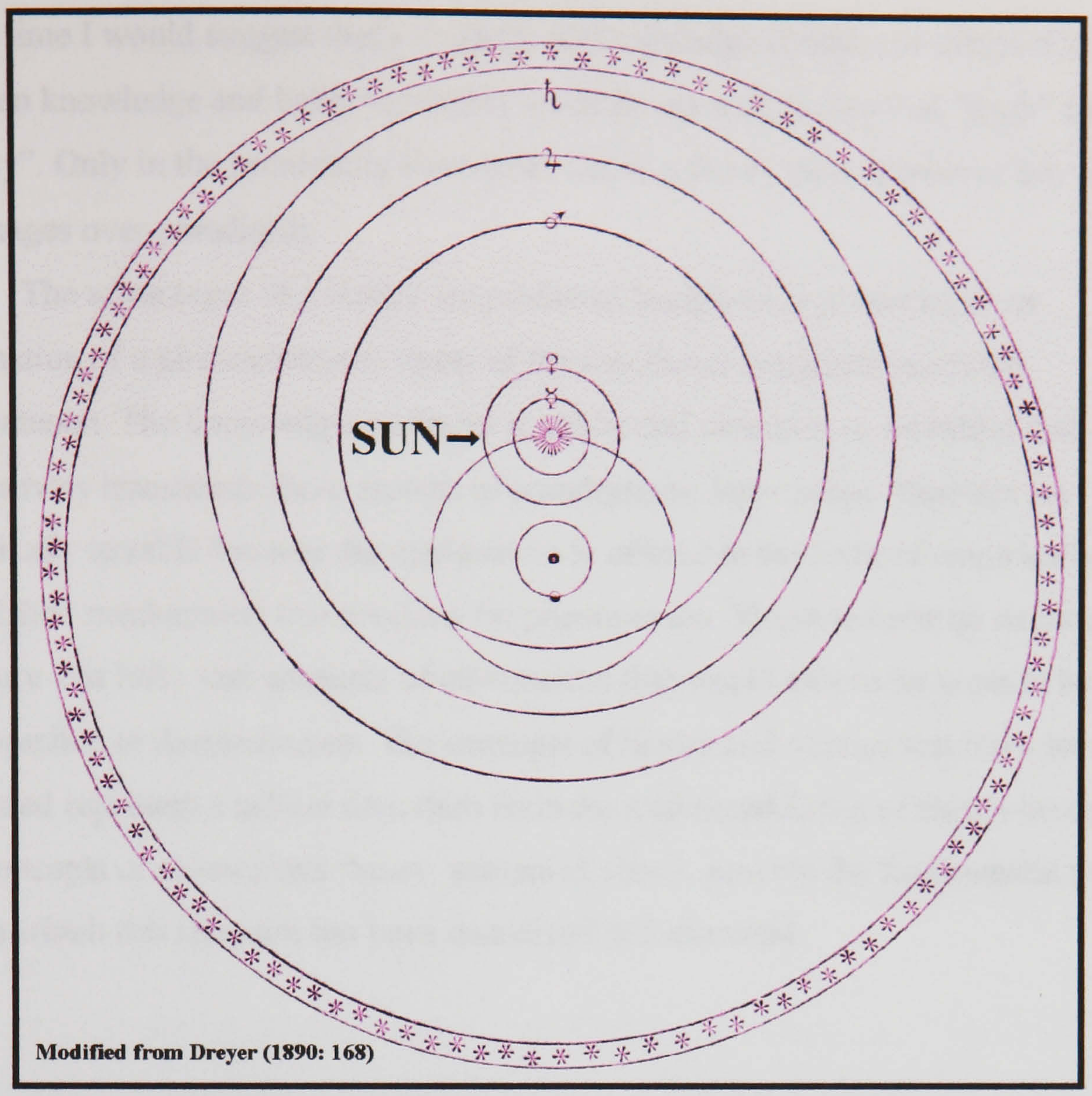

FIGURE 2.02 – This model, suggested by Tycho Brahe, is an Earth centric configuration with the Sun orbiting the Earth, but all of the other planets orbiting the Sun.

2.3.05 Concluding Remarks About Theory

The definition of a theory as an explanation based on reasonable underlying mechanisms provides a heuristic device for achieving the ideals of science – public and objective knowledge that is empirically testable. This is not an attempt to exclude paradigms from science! On the contrary, paradigms are a fundamental aspect of science and have always dominated the first phase (observation of a phenomenon and initial data/information collection). The theory phase of science simply represents the knowledge production phase of the scientific process, and it represents a qualitative increase in the quality and quantity of knowledge, which is produced as *understanding*. This is not a statement about the "truth" or "reality" of scientific knowledge, but it does express the notion that scientific knowledge (produced within the context of a theory) has definite advantages over other types of knowledge. In fact, at this time I would suggest that ultimately all knowledge (I make no distinction between knowledge and belief) probably contains equivalent levels of "truth" and "reality". Only in the proximally functional use of a theory does it achieve any notable advantages over paradigms.

The advantages of a theory are produced because it is proposed as an explanation of a phenomenon in terms of the functional mechanisms of that phenomenon. The knowledge produced is public and objective to an extent that qualitatively transcends these aspects of paradigmatic knowledge. Theories are empirically testable because the explanation is offered in the form of empirically established mechanisms that produce the phenomenon. Theories form an empirical structure that links vast amounts of information that would otherwise seem to be incompatible or discontinuous. The concepts of theory and science that have been presented represent a radical departure from the traditional forms of these concepts. The concepts of science and theory, presented above, provide the fundamental context within which this research has been conceived and executed.

2.4 NON-DETERMINISTIC SCIENCE

The example provided by Newton's theory is powerful, convincing, and compelling. But, it must be remembered that it represents a very limited perspective of the scientific process because it is "linearly causal" and highly "deterministic". In other words, the relationships within the theory are directly causal, and the condition/configuration of the phenomenon at any specified point in time can be determined by knowing the condition/configuration of the system at any other specified point in time (this assumes knowledge of any external input to the system). But many (possibly most) phenomena cannot be described as linearly causal deterministic systems. For example, Darwin's theory has been described by a number of people as being "un-scientific" because it is not a deterministic explanation of the observed facts of biology. I will use Darwin's theory to demonstrate that non-deterministic relationships can fit the structure I have outlined for theories, and that Darwin's theory does meet the criteria for the distinction between theory and paradigm just as well as Newton's theory.

2.4.01 Darwin's Theory Of Evolution

Darwin worked within the species paradigm that had been made relatively explicit by Linnaeus. Linnaeus operated within a number of paradigms (as we all do), but it is interesting that his theological paradigm included the concept that the number and forms of the species of animals was fixed at the time of their creation. According to this view some species could become extinct but they didn't evolve. The Linnaean system of categorisation represents a formal model of generalised regularities that is analogous to Galileo's Law. In other words, the Linnaean system of classification was not an *explanation* of the observed facts of biology, but it did represent an insightful methodology for classifying species into arbitrary categories, which is still employed in modern research. On the other hand, Darwin did offer an explanation of the observed facts of biology. His theory is not as explicit and formal as Newton's (partly because it deals with a system that is less deterministic and partly because there was less information available on the underlying mechanisms), but it nevertheless conforms to my structure of a theory.

As a conceptual theory, Darwin's proposition can be stated as *descent with modification*. To make this more explicit requires a bit of discussion. First, *descent* refers to the observational data that demonstrates that the physical features of animals are passed on to their progeny. The data supporting this aspect of Darwin's theory were provided by the animal breeders who had produced (and continue to produce) a very large range of varieties of animals that are *true breeding*. Second, modification required an additional mechanism, which Darwin eventually referred to as *natural selection*. The evidence for *natural selection* existed in the form of species and fossils. This takes the form of three generalisations of the observations:

1) Varieties of species that were perceived to be geographically close tended to be more similar morphologically than the species that were geographically more distant.
2) Fossils that are temporally closer (younger) to extant species tend to be more similar to them than do the older fossils.
3) All species seem to display a high degree of correlation between their physical attributes and the environments within which they live.

None of these (nor all of them in combination) constitutes a proof of the mechanism of *natural selection* but all of them in combination do constitute a reasonable argument for the existence of a mechanism such as natural selection. Darwin's theory explains the structure of the biological world in terms of the transmission of physical features by the mechanisms of heredity, and the organisation of those features into a coherent pattern of species by the mechanisms of natural selection. These two general mechanisms are sufficient for explaining the observational data of biological organisms.

One of the ways that Darwin's theory can be recognised as a theory is that it entails a specific phenomenon or set of observational data just as does Newton's theory. For example, the *paradigms* of evolution, force, and inertia can easily be used in discussions of celestial mechanics, biology, political science, economics, history, music, literature... This is due to the fundamental features of paradigms – they are infinitely accommodating, do not entail data, and cannot be used to direct research. On the other hand, Darwin's *theory of evolution* cannot be applied to celestial mechanics because the *mechanisms* of heredity and natural selection are incongruous in that context. This can also be seen in Newton's theory because the *mechanisms* of gravity and inertia are not meaningful aspects of biological organisation, political science, economics...

The Linnaean system of classification conforms to the *paradigm methodology*, and it is fundamentally an *argument* about the meaning of aspects of organisms and how they are organised. On the other hand, Darwin's theory constitutes an *explanation* of the observed organisation of biology based on the underlying mechanisms that produce it. Linnaean classification doesn't explain anything; it simply provides a systematic ordering of the diversity observed in biology. As an explanation Darwin's theory is potentially testable, but Linnaean classification is not testable. On the other hand, the fact that the Linnaean scheme seems to fit nicely into the view produced by Darwin's theory is a potential source of confusion. The Linnaean scheme can be distinguished from a theory-based methodology because it could have contained several classes of angels (Blunt, 1971). This inclusion of mythical elements demonstrates that his system of classification was based on high-level concepts and some circular arguments (which is a fundamental aspect of a top-down methodology). Darwin's bottom-up explanation of the organisation of biological variability could not include any angels because there is no observational data to demonstrate or even infer their existence in a biological scheme that is based on a scientific theory.

The fundamental difference is that Linnaean classification is a subjective argument about the nature of the organisation of biological variation. Linnaeus' argument can include any concept that he feels is relevant to the topic, and it is virtually impossible to demonstrate that any of his arguments or classes of organisation are not valid. On the other hand, Darwin is constrained to dealing with the observable phenomena that his theory can potentially demonstrate to be the result of processes or underlying mechanisms, which can be established or at least inferred from some data set. Within the context of our subjective experiences subjective arguments can seem to be no different than objective explanations, but they are fundamentally different. Both subjective arguments and objective explanations are required in a well-rounded science, but it is important to be aware of the distinction.

Darwin's theory is a non-trivial explanation for three reasons. First, it explains a substantial aspect of nature (the existence of the patterned forms and functions of all organisms). Second, it reduces a vast amount of observational data to a finite and small number of mechanisms or processes. Third, it produces knowledge that is objective and public. Two examples of valid forms of theory have been provided based on the work of Newton and Darwin. Keeping these examples in mind, I will now proceed to the conceptual formulations that are typically accepted as *theory* within the field of Anthropology.

2.4.02 Anthropological Theory

This discussion of the paradigms that typically pass for theory in anthropology and archaeology is not presented within the context of the discussions or debates about whether anthropology (or archaeology) is or should be a science. Specifically, the discussion of the Marxist model should not be construed as an indication that it is being presented as a scientific model or that any anthropologist or archaeologist that conducts research within the Marxist model would claim that they are conducting scientific research. This example is provided simply to clarify my distinction between paradigm and theory, and to indicate what logical implication can be inferred from the form of research that results from within a paradigm as opposed to a theory. This section will demonstrate that archaeological (and anthropological) *theory* is not in the form that I suggest is essential to the ideals of science, which form the foundation of the unity of research within scientific endeavours. One of the implications of this fact is that archaeologists are conducting their research within a paradigm-based methodology, which effectively precludes their work from achieving the ideals of science. The main thrust of my thesis is that scientific theory is possible for archaeological research, archaeological research would benefit from such theory, and such a theory can be applied to archaeological data. Finally, the conceptual theory that I will present (the Complex-Systems Theory of Culture) is capable of fulfilling the requirements of science so that archaeology could be *scientific* in just the same way as physics or biology.

Anthropological research is a good example of the paradigm phase of science. The concepts that pass for "theory" are examples of the *paradigm structure* and not the *theory structure*. To demonstrate this point, I will briefly discuss one of the most explicit concepts that is employed as *theory* in anthropological research – Marxist *theory*. Marxist *theory* is used to demonstrate the paradigm features of anthropological *theory* because it is explicitly constructed – not because it is suggested to be a scientific theory.

According to McLeish's (1969) discussion of Marxist ideas, it is clear that the focus of Marxist *theory* is rather narrow. Marx was not interested in human social behaviour in general; he was focused specifically on the transformations of human social relations that have traditionally been referred to as "revolutions". Marxists are working within a limited set of social behaviour, so any theory that is developed would be a *special* theory and not a *general* theory. It is my contention that Marx's concept of social revolution does not meet the requirements of a theory (neither special nor general), and it is just an example of one of the many competing explicit paradigms that exist in anthropological research.

McLeish characterised Marx's view of social change as follows:

> "... the idea of *progress* which operates through a dialectical conflict to be found as a universal principle at the roots of being, the basis of which is material existence. It is a conception of development from the most simple to the most complex. According to Marx's view, there is an impulse *within matter itself* which drives everything towards change." (McLeish, 1969: 2)

This is obviously not a formal deterministic theory (such as is Newton's), but it appears to resemble the conceptual structure of Darwin's theory. Marx's concept of social change cannot be excluded from the theory category simply because it is not a formal statement of relationships.

A theory must state the relationships of a phenomenon in terms of underlying mechanisms. Marx's proposition states that social revolutions are caused by "dialectical conflict", which is fundamental to the nature of all matter and all systems that are based on material elements. Superficially, the structure of the Marxist argument does seem to match the structure of a theory. The second requirement of a theory is that there must be reasonable evidence that the proposed mechanism exists, and that it is indeed capable of producing the phenomenon. Two criteria have to be met: 1) there must be reasonable evidence to suggest that there is a mechanism that can be called "dialectical conflict", and 2) the mechanism must represent a non-trivial explanation of social revolutions. Marx employed causal concepts from Hegel, which McLeish (1969: 3) describes as "general laws of cosmic development". McLeish provides these examples of Hegel's 'laws', 1) quantity into quality, 2) contradiction as the basis of change, 3) the negation of the negation. These represent high-level conceptual notions that are analogous to Aristotle's 'cosmic spheres', 'circular motion', and 'uniform motion'. They are not analogous to explanatory mechanisms such as Newton's 'universal gravitation' or Darwin's 'heredity' and 'natural selection'. I would argue that *dialectical conflict* does not qualify as an underlying mechanism in the structure of a theory for three reasons. First, the concept of dialectical conflict is based primarily on a circular argument. The argument takes the following form: dialectical conflict causes social revolutions because social revolutions take place and they apparently occur without external causes, therefore the internal nature of the social structure must contain the "seeds" of change. Those seeds of change are the dialectical conflicts. There is no independent data that can be used to demonstrate that "dialectical conflict" exists as a reasonably concrete mechanism.

Second, as a concept, "dialectical conflict" is ambiguous. This is apparent in the fact that dialectical conflict can easily be used to discuss celestial transformations, chemical transformations, biological speciation, or any number of other transformations. This is clearly an indication that dialectical conflict is an implicit paradigm and not an explanatory mechanism of a theory. On the other hand, it is possible that dialectical conflict is a theoretical concept that is so general as to encompass all of these other fields of research. In fact, this is close to what we are told about Marx's view. Marx regards social development as merely one special level of cosmic change (McLeish, 1969: 2).

Even if we allow that "dialectical conflict" could be seen to meet these first two criteria, there is a third way that "dialectical conflict" fails as a mechanism of explanation in a theory. The problem is that 'conflict' is not a mechanism it is a class of "conditions" that is virtually infinite in number. McLeish implies this situation when he states:

> "The Marxist must look at every social stage with fresh eyes since each has its own laws of change which must be discovered afresh."
>
> (McLeish, 1969: 81)

This is even more explicit in McLeish's discussion of the Marxist methodology:

> "In studying change, the Marxist method is to identify the *fundamental* contradiction. This provides the key which enables us to interpret and understand the whole movement in Marxist terms. At the same time we must be sensitive to the fact that we are observing a dynamic or ever-changing *process*. This means that we must expect that the principal contradiction will only be such for a limited period; new forms of struggle will appear within the reality we are studying; the unity of opposites will establish itself; the negation will be itself negated, and the new *One will* undergo cleavage into novel elements; antagonistic contradictions will give way to non-antagonistic; there will be an eternal flux." (McLeish, 1969: 9)

In other words, the Marxist proposition does not reduce a large amount of observational data to a finite and small number of mechanisms. The number of underlying mechanisms that are put forward are potentially as large as the number of observations they are purported to explain. Each one is particular to the unique circumstances of the social system. If we compare "conflict" to "gravity", we see that gravity is universal, and it can be used to identify the structure of the phenomenon that is being studied. On the other hand, "conflict" must be identified by exploring the structure that is the object of research. The same is true for the mechanism of heredity. Heredity is a unitary mechanism for all organisms; it does not have to be rediscovered every time we encounter a new species. Marxism is decidedly a paradigm and not a theory.

Marxism fails to function as a theory because of the weakness of the posited explanatory mechanism. Dialectical conflict seems to fail as an explanatory mechanism because it cannot be used to direct research and it does not provide insight into the type of data that must be engaged by research. In Newton's theory, the concept of force is used to explain the motion of all objects. There are a limited number of forces, and they constitute a highly consistent functional class. The same can be stated for Darwin's mechanisms of heredity and natural selection. Each concept can be explicitly stated to provide guidance and insight into the formulation of productive research in their specific area. Dialectical conflict is a nebulous concept, and it must be constructed in a new and particular form for each instance of social revolution. This situation does not mean that Marxism could not be a theory. It just means that, in its present form, it is not a theory.

2.5 ARCHAEOLOGY AS SCIENCE

The twentieth century contained several episodes in which some researchers called for a more scientific approach to archaeology (Wylie, 1993). In the early part of the last century several researchers explicitly called for more scientific methods that were based on hypothesis testing [see Dixon, 1913; Wissler, 1913 (from Wylie, 1993)]. In the 1930's many anthropologists became disillusioned with the sterility of historical particularism (Trigger, 1989: 22 para. 3). At this time there was a small but important move towards a science of anthropology that was founded in a systematisation paradigm and a search for general laws (Trigger, 1989) [see Steward and Setzler, 1938, Kluckhohn, 1939; Bennett, 1943 (from Wylie, 1993)]. This new perspective also called for an explicit reference to anthropological aims (Wylie, 1993). Both of these movements towards a more sophisticated theoretical position and a view to explicit problem solving based on cultural process were met by strong opposition (Wylie, 1993). For example, W. D. Strong (1936) argued that archaeology was a new science and that its proper concern should be the "accumulation of essential data", and he suggested that this focus on data collection would keep archaeologists busy for the foreseeable future (Wylie, 1993).

The latest "New Archaeology" as Wylie (1993) refers to it, emerged in the 1960's with Lewis Binford as one of its most notable proponents. The "New Archaeologists" were interested in an increase in qualitative understanding and not just a further increase in the quantity of data that was produced in archaeological research (Wylie, 1995: 19). They turned to the philosophy of science for a model that seemed appropriate for achieving an increase in qualitative understanding. Binford (1989) states that the central concern of the "New Archaeology" was the issue of assigning meaning to the archaeological record. This concern was addressed by attempts to evaluate the validity of the propositions that were used to interpret the archaeological remains. Interpretations that are based on the authority of experts were found to be less rigorous than interpretations that are based on testable propositions (Binford, 1989). Lowther (1962) stated that a central concern of the discipline of archaeology was to establish the truth of archaeological statements (Dunnell, 1995: 6). This view was seen to be either irrelevant or not scientific (Dunnell, 1995). On the other hand, this is just the epistemological view that was made popular by Binford, but the issue raised by Lowther remains unanswered (Dunnell, 1995). In other words, how can we increase the certainty of the interpretations that archaeologists assign to the archaeological data?

Traditional archaeology had found itself in the grasp of a paradox that seemed to have no solution. This paradoxical situation was caused by adopting a strict empiricist paradigm of science and at the same time adopting an idealist paradigm of causation for culture (Binford, 1989). The dominant paradigm was that archaeological remains were the result of "ideas", but there was no way of getting at past ideas so there was no way of testing archaeological interpretations (Binford, 1989). No understanding of the relationship between past ideas and the material remains they created seemed possible, and traditional archaeologists abandoned attempts to construct theories that would explain the dynamics of relationships between ideas and material residues (Binford, 1989). Inference is only justifiable when continuity can be demonstrated between the past and the present (Binford, 1989). Traditional archaeologists circumvented this paradox by stipulating an assumed linkage between the patterns in the data and the shared ideas that were seen as their cause (Binford, 1989). The "New Archaeology" focused on Hempel's philosophy of science and an interest in pursuing the discovery of laws because a universal law was *true* in all places and at all times. This atemporal nature of laws was seen as a solution to the archaeologist's problem of connecting the observed data [the archaeology] with the object of interest [the causes of behaviour in the past] (Dunnell, 1995: 6).

Another typical paradox within archaeological research is provided by the dichotomy between *natural* and *human* causes (Binford, 1989). Humans are intentional agents and culture must be explained in terms other than those used to explain natural phenomena, which are not produced by intentional agents. This paradox may be an aspect of the post-processual critique, which will be discussed below.

The "New Archaeology" has become associated with neoevolutionism (Trigger, 1989: 23). This is probably a matter of historical accident. Anthropologists were searching for structuring propositions to guide their research just at a time when the evolution paradigm was achieving prominence in a number of fields. Typically neoevolutionism was expressed as a form of technological, ecological, demographic, or economic determinism that was used to explain cultural change (Trigger, 1989). In a similar manner, the typical association of the "New Archaeology" with General Systems Theory is also a matter of historical accident. In other words there is nothing fundamental about the processual paradigm that dictates either a neoevolutionary or systems approach.

The post-processual movement has emerged as a critique of and a reaction to the "New Archaeology". Post-processual archaeology is a mixture of a general critique of the scientific methodology and a specific critique of the processual methodology that was adopted to produce a scientific archaeology. For example, one aspect of the debate about archaeology as a science is found in the concept of science as a *generalising methodology*. The post-processual critique argues that both the individual and important cultural variation is lost in the generalisation of data. Yoffee and Sherratt (1993: 1) state that "post-processual" archaeology is a critique of earlier modes of explanation. They are characterised as *behaviourist*, *functionalist*, *positivist*, or *evolutionist*, and they are typically described as flawed because they fail to consider *cognition*, *structuration*, *the individual*, and *the arbitrary nature of the sign* (Yoffee and Sherratt, 1993). To understand this critique we must engage what it means for science to be generalising and in what way is science generalising. Ingold (1996) suggests that:

> A generalization is a covering statement about the whole, as opposed to statements about its parts... (Ingold, 1996: 6)

This statement seems to imply that science seeks to engage in research by formulating "covering laws", which encapsulate data or observations. Such a covering law was discussed in the form of Galileo's Law, which indeed is a generalisation of observations on *falling* objects. On the other hand, there is no known process by which explanations, such as Newton's theory, can be generated from covering laws, such as Galileo's Law. The debate about science that revolves around the view of science as a generalising endeavour has misconstrued what is generalised and how it is generalised.

Galileo's Law generalises directly from observation, which is one of the reasons why it is merely a subjective description of the observed phenomena. On the other hand, Newton's theory generalises by providing an explanation of phenomena based on an underlying mechanism that is common to a wide range of phenomena. It also generalises by stipulating the form that data must take to engage the theory, which generalises the data for a wide range of phenomena. But this form of generalising maintains the ability to deal with the unique and particular, and it does not obliterate the individual instance of a phenomenon under a general description. Science is not meant to be the type of generalising methodology that Ingold (1996) discusses, and the ideals of science (objective explanations that produce testable and repeatable knowledge) cannot be achieved within the type of generalising science that he discusses. This position will be discussed in more detail with regard to Binford's methodology for constructing theory.

Ian Hodder's "contextual archaeology" is presented by trigger (1989) as a rejection of the neoevolutionism of the "New Archaeology". The contextual argument seems to be that it is necessary to examine all possible aspects of an archaeological culture in order to understand the significance of each part (Trigger, 1989). From this perspective all data in an archaeological site is relevant and must be considered. In contrast, a theory-based approach to archaeology specifies the appropriate data to be considered by the means of the propositions that explain the phenomenon. The contextual approach must engage an infinite amount of data without any indication of what data may be pertinent or more important. The theory-based approach has a finite data set that is specified by the propositions of the theory that constitute an explanation of culture.

A second aspect of the general critique of science is epitomised by the work of Karl Popper (1959), which Ingold (1996) summarises as the fact that any given hypothesis cannot be proven it can only be falsified. David Hume (1777) established that knowledge can be neither verified nor falsified (due to the fact that the context necessary to both of these endeavours contains untestable assumptions) tends to undermine Popper's work, and this issue is rarely engaged by adherents of the Popperian view of scientific methodology.

Lewis Binford is one of the most prominent and vocal proponents of the view of archaeology as science. Binford's view of archaeology as a science will be the focus for this discussion. This section consists of a general discussion of two aspects of Binford's views 1) Binford's conceptual view of science, and 2) Binford's methodology for pursuing archaeology as a science through the process of theory building. His general concepts of science are compatible with the process discussed above, but his methodology is based on Hempel's development of the *covering law* (CL) model. This philosophical foundation does not typically produce the type of 'theory as explanation' that is necessary to produce the objective and public knowledge that Binford states is the goal of science.

The clearest and most detailed exposition of the CL model is attributed to Hempel (1965) by Morgan (1973). The essential proposition of the CL model of explanation is that the phenomenon to be explained must be subsumed under some general principle or *law* (Morgan, 1973). This is a deductive model, and it requires two aspects – 1) a law, and 2) a description of the particular circumstances of the phenomenon to be explained. For example, using Galileo's Law and the information that an object, which was initially at rest, has fallen in an unobstructed trajectory for one second, we can deduce that the object has fallen 16 feet and that the object has an instantaneous velocity of 32 feet per second. Referring back to the discussion of Galileo's Law that was presented earlier in this chapter, it should be obvious that the CL model of explanation is not adequate for constructing the conceptually objective forms of theory and explanation that must be used to achieve the ideals of science that are proposed by Binford for archaeological research.

2.5.01 Binford's Concept Of Science

Binford's view of science appears to be a traditional mixture of the process of acquiring knowledge and the ability to demonstrate the relative validity of that knowledge. This is seen in Binford's rejection of the notion that science is committed to "laws" and "determinacy". He characterises science as the production of knowledge based on the assumption that "...the external world is knowable, and knowable in terms of itself." (Binford, 1989: 69). Scientists bring every tool available to the human mind and every advantage of experience to this task. Binford has stated a number of challenges for producing knowledge for which science must provide the answers (Binford, 1989: 34, 36, 41, and 50).

1) Scientific theories explain why the world is the way it appears to be.
2) Science should provide insights that guide our investigation.
3) Knowledge produced by science should be reliable.
4) Scientific inferences must be valid.
5) Validity must be based on experience that is publicly verifiable.

I take these statements to mean that Binford's view of science is similar to the one that I have stated above. In other words, science employs testable explanations to produce objective and public knowledge.

Binford's view that a theory "explains why" seems to be similar to my view of theories, but it depends on what Binford will accept as a valid explanation. For example, Galileo accepted math as an adequate explanation. Once he had rendered his observations of falling objects into a formal mathematical model he felt that their motion was thoroughly explained. Binford does not develop an explicit statement of what constitutes a valid explanation, but he does mention several times that science seeks to *explain nature in its own terms*. I interpret this as an objective view of science that conforms to my structure of scientific theory. Still, it is not clear exactly what these statements mean without a more explicit development of the concept of "explanation". For example, Galileo could have believed that math represents some universal cosmic attribute of things; therefore *math* would constitute an explanation of anything "in its own terms". It is likely that Binford accepts Hempel's view of explanation. Hempel (1965) states that any proposition that conforms to the CL model represents an adequate explanation, but the CL model does conform to my description of a theory. The CL model typically produces explicit paradigms, which are not adequate for ensuring the public and objective aspects of science that Binford seems to be proposing for archaeological research.

The last four challenges on Binford's list I interpret as statements about the public, objective, and empirically testable nature of scientific knowledge. These challenges seem to be equivalent to the *ideals of science* that are expressed in my description of what constitutes a scientific theory and how theory is the key to achieving scientific ideals. For example, a theory explicitly explains how a phenomenon is produced by its inherent mechanisms. The stated relationships between the mechanisms and the phenomenon provide the insights that can guide research (Binford's challenge 2). Another example is found in Binford's statement that scientific knowledge can be validated by subjecting it to empirical tests and by achieving conceptual objectivity. I infer Binford's demand for conceptual objectivity from the statement that scientists must achieve "... intellectual independence between our tools for experiencing and our tools for explaining".

The last challenge on Binford's list is addressed in the following statement:

> "The successful sciences have made great progress in developing ways to ensure that words are not cheap. ... It is standard practice to seek in experience an arbiter for opposing views. Experiments are designed, the world of dynamics is investigated. When a claim about nature is made, the research task is clearly to design ways to evaluate it. ... There is a feedback between words, ideas, positions, and experience. The result is that learning occurs."
>
> (Binford, 1989: 487)

Binford states these as individual aspects of our research, but in my view of science these objectives are attained as a consequence of moving from the paradigm phase to the theory phase of science. At a conceptual level Binford's view of science seems to be similar to the model of science that I have outlined above. He states that the acquisition of knowledge is the goal of science. The objectivity of science is evident in his view that phenomena can be understood in their own terms (not just from the perspective of the researcher). Understanding nature in its own terms also makes the knowledge public. Altogether, these statements indicate that Binford's view of science incorporates most of the important ideals to which traditional scientists have aspired. I contend that Binford's concept of science is very similar to mine, but his stated method for achieving the ideals of science is very different from mine. The following discussion will demonstrate why Binford's theory-building methodology apparently fails to achieve the stated concept of science.

2.5.02 Binford's Theory Building Methodology

The last two decades of the twentieth-century has been characterised by a growing sense of dissatisfaction with the New Archaeology attempt to make archaeology more scientific by employing the philosophy of science (Kelley and Hanen, 1988: 23). Kelley and Hanen (1988) suggest that one of the reasons for this is that this New Archaeology has largely failed to provide any new substantive understanding within the discipline. Many reasons can be stated for why so little progress has been made. Kelley and Hanen (1988) suggest that it is due to the fact that archaeologists did not understand what philosophy does. Archaeologists were seeking models for how to do science, but philosophers produce arguments about what science is, which are based on subjective assumptions such as truth, reality, rationality, etc. In other words, philosophy of science is engaged in the issues of philosophy and not in providing functional models for scientists. Whatever insight philosophy does provide for scientists must be viewed from a highly critical perspective. An example of this problem is that philosophers have traditionally sought to provide models for the justification of scientific conclusions and not ways by which those conclusions can be discovered (Kelley and Hanen, 1988: 24).

Archaeologists who wanted to move toward a scientific methodology were interested in producing work that was "objective, testable, and capable of being built upon by other researchers" (Kelley and Hanen, 1988: 165). This adequately characterises Binford's concepts of science, but his methodology for achieving a scientific archaeology has failed to produce the results that were expected. I suggest that my model of science provides insights into why Binford's methodology is not adequate for producing the results that were promised.

Binford states that archaeologists have to accept the task of producing theory for this new science because no other scientists are studying the phenomena of the archaeological record (Binford, 1989: 18). This may be a valid observation, but he may not have gone far enough. Archaeologists (indeed all scientists) may need to formulate their own philosophical foundation for science because traditional philosophy of science has an agenda that is not aligned with the agenda of scientists. These two agendas may be incompatible and contradictory (van Fraassen, 1995: 214).

Binford suggests that archaeology, as a science, attempts to know something about the past by employing reliable inferences from the data to the phenomenon. He begins with the idea that we must construct a way of removing our interpretations from the level of direct interpretation of the data (Binford, 1989: 4 and 35), but he rejects Hodder's suggestion:

> Theories basic to archaeological knowledge must be concerned with the principles according to which individuals construct their social worlds.
> (Hodder 1985: 13)

Binford rejects this method because Hodder implements it by suggesting that we can clear our minds of bias and directly know "truths of humanity". Hodder's concept is sound, but his method is not scientific. For this reason Binford rejects both the unscientific methodology and the concept. In place of it he states that we can proceed by employing *pattern recognition* strategies to produce middle-range theory. He states it this way:

> "Archaeologists must face the fact that they do not study the past, they create it. What they study is the archaeological record. The created past is only as correct as the understanding of the properties of the archaeological record, and the processes that brought those properties into being. The development of

> theoretically guided middle-range research is the key to the inferential problem." (Binford, 1989: 51)

From this perspective Binford engages in the attempt to construct scientific theory through pattern recognition. This represents a clear indication that Binford conceives of theory as a fundamental necessity for a scientific archaeology.

Binford (1989: 23) states that "Science is a learning process", and that this process represents the pursuit of knowledge through the evaluation of ideas. Applying the scientific process to increase our store of knowledge is a productive enterprise, and Binford (1989: 17) states that the early productive work focused on three aspects of science:

1) Producing generalisations about the data through pattern recognition strategies.
2) Evaluating the stated links between archaeological observations and the interpretations offered.
3) Producing a testing program aimed at evaluating the utility and accuracy of ideas.

The last two of these aspects were pursued through critiques and debates. The first of these aspects was implemented as pattern recognition and the construction of middle-range theory. Archaeology was to become the science of the archaeological record and the observed patterning it contained (Binford, 1989: 18). This approach is based on Hempel's (1965) explication of the CL model. Binford's view is that pattern recognition is a method for formulating propositions that are law-like and can be use in the CL model, but this process does not produce scientific theory as I have described it. My concept of theory does achieve the ideals of science as Binford describes them, but pattern recognition does not because the immediate product of pattern recognition is only paradigms because patterns do not provide explanations. The task of moving from a paradigm to a theory cannot be achieved through pattern recognition.

Binford appears to make a distinction between paradigms and theories, but this distinction is not clearly or explicitly developed. On the other hand, he does make a clear statement about what a theory is:

> "Since theories treat the world of dynamics, the world of interactive causation, they are concerned with why the world is the way it appears to be, and they are almost inevitably about relationships between characteristics or states of nature." (Binford, 1989: 36)

This quotation states that a theory is an explanation of a phenomenon and not just a description of a phenomenon. This statement of what constitutes a theory is compatible with my development of the structure of a theory, but Binford's methodology does not produce theory.

Binford embarked on a research design to discover inferential "laws" for interpreting the archaeological record that were based on establishing patterns of links between behaviour and material components of culture. This perspective can be criticised on two accounts, 1) "laws" produced by the process of pattern recognition fail to fulfil the goals stated, and 2) behaviour can not be used as an adequate "explanation" of culture.

One of the goals that Binford (1989: 35) states for a scientific archaeology is that it must be objective, but he also states that archaeological theory is to be formulated using "pattern recognition" techniques. Pattern recognition does not eliminate the subjectivity of observation, which means these two statements are not only incompatible but also contradictory. In my discussion of Galileo's Law I demonstrated that his formal description of the motion of falling objects was subjective because it could not be disengaged from the observer's perspective. Galileo's Law represents the epitome of the pattern recognition methodology, but his law doesn't represent conceptually objective knowledge. All pattern recognition techniques are subject to this criticism. In other words, pattern recognition will always result in a subjective description of the observer's perspective of the data even if it attains the epitome of formality displayed in Galileo's Law. The best that pattern recognition can achieve is a higher level of generalisation of subjective observations. For example, by recognising a pattern in the data a researcher can move from a specific statement (such as "this crow is black") to a general statement (such as "all crows are black"). Pattern recognition cannot be used to explain why the condition exists or provide insight into how to discover why the condition exists. Even more problematic is the fact that observed patterns are rarely meaningful statements about what fundamentally constitutes a phenomenon. For example, the quality of "blackness" may be an universal attribute of crows, but it is not realistic to claim that "blackness" is a fundamental aspect of what constitutes a crow. Pattern recognition typically engages superficial attributes of a phenomenon, such as "blackness" for crows. This is an example of why paradigms do not entail any specific data, cannot be used to direct research, and are not amenable to empirical tests.

The second way that Binford's methodology for constructing theory can be criticised is his proposal that behaviour can be used as an explanation of the material components of culture. Behaviour can't be used to explain culture because the set of behaviours needed to explain culture would be as large as (or larger than) the set of cultural phenomena that are to be explained. In other words, behaviour would be a trivial explanation of culture because behaviour is not a finite (and small) set of mechanisms that can be used to explain a much larger set of observational data that represents a phenomenon. If it were a non-trivial explanation you could increase the size of the set of observations without having to increase the set of mechanisms needed to explain them. For example, the mechanism of heredity plays a non-trivial role in the explanation of biological evolution. First, there are a limited number of strategies by which all living organisms produce offspring. Second, each strategy encompasses a large number of species. Finally, all strategies of inheritance can be reduced to the transmission of genetic material. On the other hand, *behaviour* as an explanatory mechanism is analogous to the Marxist mechanism of dialectical conflict, and behaviour fails to meet the basic requirements of an explanatory mechanism of a theory for the reasons discussed in section 2.5.2. If heredity was particular to each instance of producing a new organism then the theory of evolution would be relatively meaningless, and evolutionist researchers would be engaged in cataloguing each particular form of heredity.

As a further exploration of this point, *ideas* cannot be used to explain culture any more than *behaviour* can. One of the great achievements of anthropology has been the demonstration that behaviour and ideas are particular to a given culture and that they can be used to distinguish between distinct cultures. If extant cultures are characterised by distinct ideas and behaviours then it seems reasonable to conclude that past cultures will also be characterised by distinct behaviours and ideas. A theory that explains extant cultures in terms of *ideas* can not be used to explain past cultures because the ideas will be different and not a universal mechanism. *Ideas* also represents a set of conditions as large as *behaviours*, so even if we accept *ideas* as an explanation of culture it would be as trivial as an explanation based on behaviour. *Ideas* are as much an integral part of cultures as are artefacts. We need a theory that explains *ideas* and *behaviours* as well as *artefacts*. Pattern recognition and middle-range research cannot address this goal.

Middle-range research (and pattern recognition) cannot produce a non-trivial theory of culture (or the archaeological record). Middle-range research is conducted within a paradigm (not a theory) and can only accomplish those things that can be addressed within a paradigm. Middle Range Research can be used to increase our knowledge of observational data, increase our knowledge of the target phenomenon, and to describe our observational data in more formal terms. We can even reject some notions about how the phenomenon behaves, but Middle Range Research does not fit the structure of a theory and does not address all of the challenges of scientific knowledge.

2.6 CONCLUSION

In "Archaeology: The Loss Of Nerve" (1993) Richard Bradley expressed the view that archaeologists have lost faith in the archaeological record. He states that archaeologists who would be scientists have been forced to study the minutely physical, and that this is far from what archaeologists want to study – namely human behaviour. It seems that almost every notable author within the field of archaeology has remarked at one time or another that the archaeological record is incomplete, degraded, or inadequate. On the other hand, my view is that "data" is not the backbone of science – theory is. It is archaeological theory that is inadequate. Theory, as it exists in archaeology, fails to provide an adequate framework for engaging the data and allowing archaeologists to produce reasonably concrete and justifiable reconstructions of the behaviours and social organisations of past cultures.

This chapter is an attempt at outlining a model of the type of theory that is required for achieving the ideals of scientific research - objective and public knowledge. This model is based on a distinction between paradigms and theories that is similar to Nagel's (1961) distinction between "common sense" knowledge and "scientific" knowledge. Nagel's view of scientific knowledge is that it contains explanations that are reliable and testable. Common sense provides fairly reliable knowledge, but explanations are either absent, unreliable, or untestable (Nagel, 1961). I suggest that paradigms and theories are systems of beliefs, and that what distinguishes theories is their structure of explanation. Theories explain phenomena based on underlying mechanisms that can be demonstrated to be relatively reliable and testable. This structure makes the knowledge produced by theories conceptually objective while paradigmatic knowledge is fundamentally subjective. By employing this description of theory I have demonstrated that the concepts that pass for theory in the field of archaeology are merely paradigms and are therefore inadequate for producing scientific knowledge about past cultures.

Traditionally these types of critiques of archaeology have stopped at the point of revealing the inadequacy of our endeavours. I have stepped beyond this point by suggesting that a scientific theory of culture can be constructed. It is an information theory that is based on Implicit Learning Theory and Dynamical Systems Theory. In the following chapters I will develop my theory, which I refer to as the *Complex-Systems Theory of Culture*. In the final chapters of this thesis I will demonstrate that CSTC can be productively employed in the analysis of archaeological data. This effort will demonstrate that CSTC is not only conceptually adequate but also capable of engaging data and directing research. This accomplishment should vindicate Binford's belief that science can be useful to the field of archaeology, and that archaeologists at all levels of research can benefit from the application of a scientific methodology that is based on scientific theory.

CHAPTER 3

GENERAL SYSTEMS THEORY AND ARCHAEOLOGICAL RESEARCH

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General Systems Theory (GST) and its application in archaeological research provides a context for my research, which involves Dynamical Systems Theory (DST). GST became a significant perspective in Archaeology in the 1960's. Butzer (1982) attributes this to the "great debate" that marked the transition from the "Old Archaeology" to the "New Archaeology". The "New Archaeology" emerged from the adoption of new goals for archaeology. One of the goals of the new archaeology is the production of interpretative content that can be used to relate archaeological research to broader issues of anthropology and the other social sciences (Redman et al., 1978). This issue was addressed through the adoption of methodology and theory from related fields and GST was one such tool that was widely employed in this new enterprise.

The systems approach was borrowed by archaeologists from closely related fields and adapted to their specific needs. This can be seen in the type of models deployed (as with the ecological models from biology [see Waddington's (1959) *Evolutionary Systems - Animal And Human.*]), and in the terminology used (such as the 'Principle of Least Effort', which is an expression of a principle of thermodynamics that has been adapted for and employed in economics).

The structure of this work is to present a summary of GST that highlights some of the more relevant aspects that are employed in archaeological research. The second section will present a description of GST in archaeological research and will present a few examples. The third section will be a discussion of the use of GST in Archaeological research. The fourth section is a brief conclusion that will integrate this work with my research issues.

3.1 GENERAL SYSTEMS THEORY

General Systems Theory is an eclectic accumulation of techniques and models, each tailored to a specific application within one of the many diverse fields where it is commonly employed (Bellany, 1997). The systems approach does have several aspects that are common to most of its applications, which are rarely explicitly stated. The first, and possibly the defining aspect of the approach is the concept of the whole, which is expressed in this definition by Berryman:

> "Any system ... is basically composed of a set of interacting parts which, together, produce patterns of behaviour which are characteristic of that system." (Berryman, 1981: 1)

This is just one of many definitions of a system; Jordan (1965), for example, has compiled a list of fifteen. The important thing is that a problem or phenomenon is perceived to be the result of many interacting parts or elements. The phenomenon to be studied or controlled is a consequence of how these parts come together and interact. This requires us to acknowledge that the system has both structure and function. For example, a clock can be considered an example of a system because its parts interact with each other in a specific characteristic manner, but a bag full of random objects is not a system because the arbitrary removal or addition of objects does not alter the characteristic behaviour of the bag or its collection of items. Some of the common aspects of a system will be briefly discussed to provide a sketch of systems methodology as a context for discussing the application of systems thinking in archaeology and specifically the origins of agriculture.

3.1.01 Sub-Systems

A fundamental part of systems theory is that a system contains elements that can be grouped into sub-systems from either a structural or a functional interpretation. This facilitates our ability to understand systems, and it can be seen as a heuristic for designing systems through engineering processes. Bellany succinctly states this in the following:

> "... knowledge is a unity, but ... understanding can be advanced only by breaking up the universe of knowledge into intellectually manageable parts." (Bellany, 1997: 183)

The concept of sub-systems is developed as an extension of the holistic approach in systems theory. It affords increased attention to detail, reduction of system complexity, and increased focus of analytical investigation. For example, a designed system, such as a clock, has several sub-systems that can be structurally isolated for design or analysis. In a simple clock that has only three functions (namely indicating the current representation of temporal units, such as seconds, minutes, and hours) the clock can be broken down into sub-systems that correspond to these three functions (which are all observable phenomena of the system). Considerable reduction in the complexity of the system can be achieved by assuming that two of the three sub-systems represent constants as far as structure or function are concerned. Investigation or design considerations are facilitated and simplified by this process.

An important aspect of the sub-system concept is that it is dependent on the perspective of the people who define the system (Checkland and Scholes, 1990; Reynolds, 1981). In the above example the clock was broken down into three sub-systems based on the observable behaviour of the system in question. A design approach to conceiving a new clock that has those three functions might divide the clock into four or five, or even more, sub-systems. For example, another sub-system might consist of the parts that comprise the case of the clock, or the hands and the face, or the spring and its winding mechanism. Sub-system definition depends on which relationships are deemed to be significant or critical to the task (which could include design, analysis, representation through modelling, etc.) by those persons involved in the endeavour

Once defined the elements and sub-systems are typically treated as concrete units or objects. This facilitates the project, but it is also a significant source of bias and error, and it can result in the failure of GST models.

3.1.02 Hierarchy

The concept of hierarchy in systems thinking is a logical development of applying this methodology to increasingly complex systems. As the complexity of a system increases the typical response of those who are modelling the system is to group the increasing number of sub-systems into a hierarchical structure. In the simple clock example there is little need for a hierarchy to deal with the subsystems (especially with the conceptual model that uses only three sub-systems). But, if we were to apply systems theory to a more complex clock, one that displays the day of the week, the month and day, lunar cycles, and also chimes; it becomes much more likely that the number of sub-systems would increase to the point that the systemic representation of this complex clock would be facilitated by a hierarchical structure.

The hierarchical structure of a system is just as arbitrary as the sub-systems are. Each researcher, or designer, will see the system from a unique perspective, and that perspective will lead to a relatively unique hierarchy. The range of variation is so great that for virtually every system two perspectives can be found that produce hierarchies that are opposites of each other. In other words, one view has a specific sub-system at the top of the hierarchy, and another view will place the equivalent sub-system at the bottom of the hierarchy.

As with sub-systems, once the hierarchy is defined it is typically treated as a concrete structure. This results in the same facilitation of effort, and the same generation of problems as does defining sub-systems.

3.1.03 Closed Systems

The closed system approach has been the epitome of the scientific endeavour for as far back as it can be traced. For example David Hilbert was convinced that all of mathematics could be reduced to a collection of formal statements using a finite alphabet of symbols and a finite set of axioms and rules of inference (Dyson, 1995). This could only be done if mathematics is a closed system, and Godel proved that it is not (Dyson, 1995). The particle theory of physics is another example of the closed system approach. The search for the fundamental particle that comprises all of matter is based on the idea that matter represents a closed system, no one has proven the contrary as yet, but it is probably only a matter of time. The reductionist regime is based on the concept of a closed system and has been employed to great effect and to the virtual exclusion of any other methodology in the 'hard' sciences. This bias has come along with the systems approach into the social sciences.

One of the aspects of systems thinking in Archaeology is the common use of closed systems. This could be a bias of systems engineering that was transmitted to Economics and taken in by Archaeologists. An engineer applies systems theory to a designed system that is circumscribed by the fact that the parameters of the system (what it should do and in what environment) are clearly defined and stated before the system is designed. As a result the system engineer can work within a closed system concept where the environment is irrelevant (Checkland and Scholes, 1990). Economists have taken this on board. In realising that the environment contains too vast a number of variables to be effectively dealt with, they apply a closed systems methodology, which is evident in the often-used caveat "all things being equal".

In the example of the clock, the systems approach that has been outlined so far is a closed system approach. The clock is conceptually represented in a vacuum, and this is acceptable as long as the clock is used within the context of its design. This context is assumed by the design process and is stable to such a degree that no design elements must take into account any changes in this context. The problems that arise when you take a clock on board a sail boat that goes out to sea are immediate and obvious. This is because the assumed constant momentum of the household context is not the same as the changing momentum context of a sailboat at sea. This acknowledgement of the effects of the context of the system has resulted in another common element of systems thinking, the system/environment dichotomy.

3.1.04 Systems And Environments

Another fundamental aspect of the systems approach is the awareness of the context or environment of the system. Even when the system is considered as a 'closed system' and its environment is assumed to be irrelevant or a given constant, the environment is usually mentioned as a frame of reference for perspective. This is part of a trend in science that crystallised with Einstein's theory of relativity. The basic concept here is that nothing exists in a vacuum, or in other words, nothing is context-free. What Einstein demonstrated was that even the 'laws of physics' were not neutral with respect to inertia. The system/environment dichotomy is often used to set up the context of change with the mechanisms of the system producing stability and the perturbations of the environment producing change. This can be seen as a continuation of the school of thought that has been labelled 'environmental determinism'.

The system/environment dichotomy is often used to help define the system. It can be used to show what the constants are that form the parameters within which the system operates or it can be used as mentioned above to separate the parameters of stability of the system from the parameters of perturbation that act on the system from an external perspective. The developing complexity of the interaction of the system with its environment has produced some dramatic changes in systems theory, and these will be addressed briefly in the discussion section of this essay.

3.1.05 Designed Versus Evolved Systems

Much of the conceptual foundation of systems theory was developed with respect to the design of engineered systems (Checkland and Scholes, 1990). Mechanical and Electronic systems are made of discrete parts that can be assembled and dis-assembled. Their function can be analysed and they can be arranged in sub-systems that fit into a specific hierarchy. This has been taken into biology and the social sciences with the effect that some authors explicitly refer to natural systems as having been 'designed by evolution' (see Pinker, 1994; Barkow, Cosmides, and Tooby, 1992). Natural systems cannot be dis-assembled, and they are not comprised of discrete parts. The reductionist regime has worked along these lines for many years, but it is increasingly obvious that this is a superficial approach that yields only minor success in gaining knowledge of and producing explanations of natural systems.

Designed systems are systems because they were defined as systems in the designing process. Natural systems may not be systems at all, it must be remembered that we are employing a systems context to understand natural phenomena, but this is just a heuristic and not a statement of the reality of nature as a system (Checkland and Scholes, 1990). Any natural system is a system only in the sense that we are defining it as a system in an attempt to employ the best model we have for trying to gain more knowledge about natural phenomena. This fact is often overlooked, and is evident in the typical treatment of elements, sub-systems, and hierarchies as concrete objects and structures.

One of the most dramatic differences between natural (or evolved) systems and designed systems is that the stability of the designed system decreases as elements and sub-systems are added. The natural system is the antithesis of this, and increased stability is typical with increasing elements and sub-systems. This is implicit in the concept that promoting bio-diversity is a defence against extinction events. On the other hand, increasing the diversity of a designed system typically increases the probability of catastrophic failures in the system. This fact is so prominent in the minds of systems engineers that they are often perplexed by the stability that is demonstrated by natural systems (Blackett, 1962).

3.1.06 Analysing A System

A common approach to the analysis of a system involves defining the system's static structure (Berryman, 1981), and then looking at a temporal sequence of static state descriptions to identify the relationships of the interacting parts and the state variables. The state variables are the components of the system that change in time (Berryman, 1981).

This methodology is common in archaeological research because the archaeological record is often conceived as data that represents 'snapshots in time'. By reconstructing relationships between the data at each level the archaeologist can look at how these relationships change through the levels of a sequence. This is often interpreted as representing a functioning system, which is analogous to the way a movie presents motion by presenting a series of still pictures.

3.2 GENERAL SYSTEMS THEORY AND ARCHAEOLOGY

General Systems Theory (GST) and its application in archaeological research provides a broad context for my research, which involves Dynamical Systems Theory (DST). GST became a significant perspective in Archaeology in the 1960's. Butzer (1982) attributes this to the "great debate" that marked the transition from the 'Old Archaeology to the "New Archaeology". The old archaeology was typically involved in the establishment of temporally and spatially organised categories of archaeological cultures based on artefact types (Higgs and Jarman, 1975). This can be seen in the focus on traits and sequences of 'cultural types' that was used to produce temporal and spatial organisations of typologies (Redman et al., 1978). The continuing collection of data served only to produce ever-increasing detail and division of typologies into more complex arrangements. One aspect of the "great debate" was a growing frustration with this narrow and limited perspective for archaeology (Higgs and Jarman, 1975).

Butzer (1982: 5) presents the adoption of systems theory by archaeologists as one of the consequences of the "great debate" in archaeology that began in the 1960's. He sees this in three works, Chorely's (1962) paper in ecological anthropology, Geertz's (1963) work *Agricultural Involution*, and Flannery's (1968) article on systems theory in Mesoamerica. Butzer (1982) sees this debate as a search for the ultimate goal of archaeological endeavours and it resulted in the end of purely fact gathering enterprises and the beginning of theoretical synthesis of facts into knowledge.

The "New Archaeology" emerged from the adoption of new goals for archaeology, and can be seen as a shift from preoccupation with a Level 1 system approach to archaeological data to a Level 2 system. A Level 1 system is a chart or map, and a Level 2 system is a simple dynamic system (such as a simple mechanical clock) (Boulding, 1978). The dynamic system represents both the structure and the function of the system by interpreting the interaction of the parts comprising the system. One of the goals of the new archaeology is the production of interpretative content that can be used to relate archaeological research to broader issues of anthropology and the other social sciences (Redman, et al, 1978). This was addressed through the adoption of methodology and theory from related fields and GST was one such tool that was widely employed in this new enterprise.

The systems approach was borrowed by archaeologists from closely related fields and adapted to their specific needs. This can be seen in the type of models deployed (as with the ecological models from biology [see Waddington's (1959) *Evolutionary Systems - Animal And Human.*]), and in the terminology used (such as the 'Principle of Least Effort', which is an expression of a principle of thermodynamics that has been adapted for and employed in economics).

3.3 GST AND ARCHAEOLOGICAL RESEARCH

General Systems Theory is used by a number of researchers to try to find explanations of cultural changes such as the transition to farming. Three examples are presented to illustrate the use of General Systems Theory in Archaeological research.

Zvelebil and Rowley-Conwy (1984) present a model of the transition to farming in northern Europe. The structure of their model is based on a simple system/environment separation. The system is represented by cultural stability and long-term resistance to the change from foraging to farming. The environment provides the source of perturbation that produces the eventual transition from foraging to farming. Two examples are presented in the context of this model, one in Denmark and one in Finland.

Coe and Flannery (1967) present a view of farming in Guatemala that contrasts the uplands to the coastal lowlands. Their model focuses on the elements of the system that could have acted as regulating mechanisms that impeded the change to farming in the uplands and the elements of the coastal system that could have become part of the positive feedback that lead to a rapid transition to farming in the coastal lowlands.

3.3.01 The Transition To Farming In Denmark

This example relies on the conceptual basis that farming and foraging represent two interchangeable but mutually exclusive elements of a system. Zvelebil and Rowley-Conwy (1984) conceive a cultural system that is stable as a sedentary village structure and that to maintain this structure in the face of environmental change the system switches from a predominantly foraging economy to a farming economy. This is a limited transition where the structure of the system is maintained by a dramatic transformation of a limited number of elements or sub-systems. Zvelebil and Rowley-Conwy suggest that these two economic strategies are incompatible because farmers and foragers compete for land, raw materials, space, manpower, information, time, and social status. A mixed strategy where foraging and farming are both significant elements of subsistence is possible, but it requires an adjustment to the structure of the system that includes the relocation of the settlement and division of labour by gender. It is implied that these adjustments are part of the negative feedback that stabilises the foraging system and produces a resistance to changes to the structure of the system.

Trade networks represent another element of the system. In the foraging phase of the system the trade network is the source of information about farming and the means of acquiring the seeds and technology for limited 'experimentation'. After the transition to the farming phase the trade network serves as the focus of the use of wild resources, which are now used to produce fur and other items for industrial use. It is not clear where Zvelebil and Rowley-Conwy place the trade sub-system in their hierarchy, but it would seem that trade is part of a different level of the system than the subsistence sub-systems.

Their model has three phases, availability, substitution, and consolidation. In the Denmark example the availability phase lasts for over a thousand years. During this period there is evidence of specialised exploitation of marine resources, increased population density, and the development of more permanent base camps. Zvelebil and Rowley-Conwy eliminate environmental reasons for a delay in the transition to farming by claiming that the climate and soil in Denmark is at least as good as that of Germany, where farming spread rapidly a thousand years earlier.

The substitution phase in Denmark is presented as a rapid transition that is precipitated by the disappearance of the oyster (an important seasonal resource in the foraging strategy) (Zvelebil and Rowley-Conwy, 1984). There is an implicit connection between changing climate and the reduction of marine resources and the disappearance of the oyster.

The system view in summary is that foraging and farming represent two mutually exclusive sub-systems at the same level in the hierarchy of the system. An external change in climate precipitates a reduction in one of the critical elements of the resource base of the foraging sub-system. The systemic response is to replace the reduced output by supplementing with some farming, but due to the incompatible demand on resources the structure of the system is unstable and rapidly changes to a stable system by substituting the farming subsystem for the foraging sub-system and by transforming the residual foraging activity into an element of the trade sub-system.

This example is a closed system model that is very simple because very few elements are considered and very little elaboration of the system is expressed. This allows a linear causal explanation to be presented. The causal path is: climate change alters the foraging resource base, cultural behaviour shifts to compensate, the shift results in an unstable configuration, and a new stable cultural pattern emerges in the form of a transformation of the subsistence economy from foraging to farming.

3.3.02 The Transition To Farming In Finland

This example is more complex than the Denmark example. In this example the farming group migrates into the foraging regions and eventually this leads to a mixed subsistence economy. The increased complexity arises in several areas. First, subsistence is broken down into a sub-system that contains four elements - hunting, fishing, sealing, and some agriculture. Second, the distinction between foraging and farming is not a clear case of two incompatible sub-systems, as it is in the Denmark example. Foraging is distinguished from farming in the relative dependence on the four elements, and by the functional role of the elements. For example, sealing in the farming economy is seen as an element of industry and trade, where as in the foraging economy it is primarily for the acquisition of meat.

The third area of complexity is due to the migration and mixing of cultures. In the Denmark example the two cultures remain in their traditional regions and live traditional lives until the transformation occurs. In this model several types of transition are occurring and both cultures are involved in transitions. Migration serves several implicit functions in this example. (A) The different focus of subsistence economy of the two populations reduced the competition between these two groups as the farmers moved into the forager's territory, which reduced conflict and facilitated the establishment of farming settlements in foraging territory. (B) The emigrating farmers could employ a mixed economy because they were already in the process of relocation so this did not act as a resistance to adopting the mixed approach, as is suggested for the Denmark example.

The fourth area of complexity of this example is seen in the increased resolution of environmental factors behind the transition from one subsistence strategy to another. The critical element in the transition from foraging to farming in this example is the seal. The availability of this resource can be attributed to several elements of the environment. Both grey and ringed seals select calving locations based on the sinuosity of coastline, duration of ice, and thickness of ice. Two geological processes (accumulation of alluvium and emergence of lowland plains due to isostatic uplift) result in reduced sinuosity of the coastline along the central and northern Baltic. At the same time the lowering of temperature due to the sub-boreal oscillation and the reduced salinity of the Baltic Sea resulted in more extensive, thicker, and longer duration of ice along this coastal shoreline. These factors produced a change in calving (and therefore general seal population) location from the coastal shore to the islands in the central Baltic.

Again, this example demonstrates their model of cultural stability that is perturbed into dramatic transition by environmental changes that are founded in geological and climatic causal sequences.

3.3.03 Village Farming In Guatemala

In *Early Cultures And Human Ecology In South Coastal Guatemala* Coe and Flannery (1967) are investigating the 'earliest village-farming occupation' of this region. Coe and Flannery explicitly define their approach as an ecological model, which is an implicit statement of a systemic approach.

Coe and Flannery begin by establishing two distinct ecological areas, and they use the contrast to explore the elements of the system. The Tehuacan Valley is used as an example of an agricultural system that 'involved the seasonal exploitation of widely scattered natural resource areas as a supplement' to limited agriculture. Coe and Flannery establish the necessity of supplementing agriculture in this system, and they argue that the extensive distribution of wild resources militates against the formation of permanent villages in the Tehuacan Valley. In contrast, the coastal environment provides a 'lagoon-estuary system' that contains abundant wild resources and allows the establishment of permanent villages.

The broad view is that agriculture began in the uplands, was transmitted to the coastal areas through trade networks, and was the foundation of permanent villages and population growth during the Early Formative phase in Mesoamerica. In contrast to the coastal area the uplands remain a marginal agricultural area until the technological innovation of irrigation systems (and supposedly the discovery of an agricultural mix that reduced or eliminated the need to supplement with wild resources).

Coe and Flannery begin by describing the environmental elements and hierarchy of the system. Most ecological approaches to human activity are based on the scale of the biome. This is 'usually defined on the basis of differences in the climax type of vegetation' (such as grassland, tropical forest, mixed oak forest, and desert). Coe and Flannery contend that the resolution at this scale is not adequate for investigating human behaviour, and they move down to the scale of the biotope (microenvironment).

Their analysis of early farming villages in Mesoamerica is based on the elements of the environment that allow for settled life. In the upland regions of the Tehuacan Valley the resources of the biotopes are seasonal and the biotopes are too far apart to be effectively utilised from one base camp. This results in a seasonal round with an agricultural element that is scheduled in among several other elements, which all exploit wild resources. It is the reduction of spacing of biotopes in the lagoon-estuary system that allows a settled village life. In the coastal area of Guatemala, the biotopes along the tropical forests are reduced in spatial distribution so that subsistence can be directed from a single permanent base camp. This produces a condition where farming can become the dominant aspect of the subsistence economy and all of the other elements of the economy can be arranged to facilitate the exploitation of crops.

It is noteworthy that Coe and Flannery employ two concepts to present a historical perspective to their model. First is the 'Principle of Least Effort'. This is the concept that 'a person will solve his immediate and probable future problems (as judged by himself) in such a way that the minimal amount of effort will be expended' (Zipf, 1949). The second is the concept of a 'channelling effect', which is a statement of the view that what you have done in the past has significant impact on what you can do now and in the future.

These two concepts are used to explain the incorporation of a farming element within the traditionally foraging economies of these two areas. The seasonal round of the Tehuacan Valley was well established and efficient so the agricultural element was stabilised at a low level of production. The 'efficiency' of the established foraging pattern militated against changes to the subsistence behaviour, and the effort involved in increasing the farming element was greater than the return that could be produced. In other words, in the Tehuacan Valley "least effort" and "channelling effect" act as regulating mechanisms that provide the negative feedback that militates against change to the system and stabilises the system in a predominantly foraging condition.

Coe and Flannery suggest that the estuary environment allowed for a semi-sedentary mode of settlement even before agriculture. The partially sedentary estuary economy could accommodate an agricultural element and the element could expand to become the dominant element of the economic system because of the pre-established tendency toward a sedentary life and because environmental conditions of rich soil, high rainfall, high water table, and tropical climate allowed the production of two or three crops per year. In other words, the coastal estuaries provided opportunities that not only negated the regulating effects of "least effort" and "channelling effect", but they also provided the positive feedback of multiple high-yield crops that apparently resulted in a rapid change to farming.

These two examples from Guatemala illustrate that transitions within a system are significantly affected by the conditions of the system and the return on the effort involved in the change. In each case the established system accommodated agriculture in proportion to the flexibility of the system as a whole. The upland system was rigid and could accommodate farming as a minor element (until such time as farming became flexible enough to allow a further transition), and the coastal system was flexible enough to allow farming to become the major element of the subsistence economy.

3.4 GENERAL DISCUSSION

3.4.01 Defining A System

In Reynolds' (1971) view 'knowledge is a unity, but ... understanding can be advanced only by breaking up the universe of knowledge into intellectually manageable parts.' From this perspective all models are simplified abstracts of reality, and they distort reality because many elements must be left out to make them manageable and comprehensible. This is obviously a major problem for GST. There exists a fundamental and irreconcilable contradiction in a methodology that claims to be a look at the whole, but must discard most of the whole to be comprehensible. This results in the difficult task of selecting the elements that are 'critical' to the system in question. At its best the process of defining a system in GST is an almost impossible task of sifting an infinite number of elements to select the manageable few that represent the critical elements of the system. From another perspective GST is a logically circular exercise, which involves defining a system by empowering the elements that you are familiar with, to explain a phenomenon. This is a bias that exists in all models, but in GST it could represent a critical aspect of the failure of most, if not all, models. This is a theme that will be a recurring element in the subsequent points of discussion.

3.4.02 Sub-Systems And Defining A System

Coe and Flannery (1967) define some of the environmental aspects of the system they will be employing by dividing the environment into sub-system units. They suggest that there may be as many as eight biotopes (microenvironments) that are relevant to human behaviour in the coastal region and additionally employ an inland biotope that is occupied by humans for direct comparison. They only discuss the two biotopes that are occupied by humans, but by refining the scale they have done two things; first, they have defined a system that focuses on very specific aspects of the environment, and second, they have effectively discarded those aspects of the environment that they perceive as irrelevant to their analysis. This demonstrates several aspects of the system approach.

1. Natural systems are too vast to comprehend or to analyse as a detailed whole.
2. Defining the system, sub-systems, and elements is a critical task.
3. All systems are arbitrary constructs that are defined by the researcher.
4. Selecting the aspects of the system to be included in the model is another critical task.

It is not unreasonable to conclude that this methodology may possess too many critical tasks to be successful.

3.4.03 Unique Perspective

In GST each model is unique because the system is established based on the defining of the critical elements of a particular phenomenon from a particular research perspective, and this produces another fundamental contradiction. This is a systematic methodology that produces unique models that are very difficult, if not impossible, to relate to each other. They only have very superficial and general similarities that are often only implicitly referred to. This is obvious in the model presented by Zvelebil and Rowley-Conwy. They present two examples that are so different in elements, sub-systems, and structure that only the most general and superficial of comparisons can be attempted.

3.4.04 Selection Of Causal Factors

One bias of traditional science that strongly affects GST is the production of deterministic explanations that are based on linear causal interpretations. This is evident in virtually all GST models and is found in both of the models and all of the examples presented here.

In neither of these models do the authors consider that the change to farming could be an on-going cultural process that is only facilitated by the environmental conditions. In the Denmark example presented by Zvelebil and Rowley-Conwy, during the availability phase a positive feedback loop may already be in operation. This process could be slowly transforming the system, and this is suggested by the 'abundant evidence of specialised exploitation of marine resources, of increased population density, and of the development of more permanent base camps.' Rather than the stable foraging system that they suggest for the availability phase, there is 'abundant' evidence that the system is in transition long before their critical change in the environment, which they choose to put forward as the cause for the precipitous transition. Increased population density and permanent base camps are two of the defining aspects of the farming system, but they are evident in the thousand-year period before the transition. The increasing population density and the move to more sedentary base camps during the availability phase in the Denmark example could be the result of internal systemic processes as easily as environmental factors. The reduction of marine resources could be a fortuitous coincidence that merely provides a catalyst to the continuing process and increases the tempo so that the evidence for change in the archaeological record becomes more obvious. On the other hand, the disappearance of the oysters could be attributed to the increasing marine specialisation and increasing populations of the foraging groups, in which case the transition is not caused by climatic factors.

In contrast, the model presented by Coe and Flannery does address increased population and increased sedentism, but there is no explicit explanation of the move to more sedentary settlements. The implicit explanation seems to be that it is a part of the universal human nature to prefer a sedentary life to a mobile life. This is implicit in concepts such as Zipf's 'Principle of Least Effort'. Presumably, a sedentary life requires, on average, less effort than a mobile life. Another aspect of this implicit assumption may be attributed to our bias as settled modern humans. All modern populations are predominantly sedentary, and as members of a sedentary population, we may see it as the 'natural' condition for humans.

Another element that is over looked is the function of migration in the example from Finland. No explanation of the cause of the migration of the farming population is presented. They admit that migration creates a situation where the transition to farming is more of a 'moving frontier' between foraging and farming populations, but they prefer to give precedence to the changes in environment as a causal explanation of the transition. Since this model does not adequately explore the impact of migration on the transition process it is not possible to establish which of the processes has the greater impact.

Implicit in this model is the notion that the population of foragers had to become farmers. It does not consider that the population could have changed to another form of foraging or it could have emigrated or suffered catastrophic population decrease.

This is to the point of exposing several of the drawbacks of the systemic approach.

1. Natural systems can be comprised of as many elements and sub-systems as the researcher feels are appropriate. This results in a strongly circular logic.
2. Elements and sub-systems can be ignored, forgotten, and overlooked.
3. Natural systems tend to display a cybernetic regime comprised of positive and negative feedback. This means that constructing linear causal explanations always forces an arbitrary selection of starting point based on a perceived static structure with fixed elements.

On close examination GST models tend to provide explanations that do not explain a phenomenon adequately or convincingly. This may be due to the fact that they tend to focus on causal interpretations that rely on arbitrary linear constructs.

3.4.05 Structure

GST models set up static structures and try to run them forward to predict, or backward to explain phenomena. This fits archaeology because the data collected represents static instances in a temporal sequence (at its best, at its worst, archaeological data represents the undifferentiated palimpsest of the remains of events). This methodology is based on the notion that systems are made of structures and elements that are constant through time. In other words, researchers employing a GST methodology tend to formulate culture as a closed system with definable constant elements. This is acceptable in a designed system, but in natural systems elements are not easily defined and rarely do they remain constant. For example, a seal is only a seal until it becomes a fur coat, a bone tool, or lunch. Even more important, a seal may not even be a seal until it emerges as an important part of a cultural context.

3.4.06 Universal Laws

An important aspect of GST is the use and search for universal laws, such as the 'Principle of Least Effort'. I am not convinced that this is inherent in systems theory. It may be a bias of the traditional application of scientific methodology. In either case this is another distortion of reality (see Reynolds, 1971). This is one of the homogenising aspects of systems theory that masks individual behaviour and the individual's contribution to the system by focusing on the 'average' or 'typical'. Transformations depend on variation and what is rare, individual, or unique today may become the norm of tomorrow. Stability is a process of maintaining the norm; transition is the process of changing a unique thing into a norm. The application of processes of stability in the investigation of a transition is one sure way of distorting your view of the transition and missing the important elements of the system.

3.5 GST AND RESEARCH IN THE NEAR EAST

General systems theory can be applied at many levels of investigation. Three examples of systemic approaches to archaeological research in the Near East are presented here. First, C. L. Redman presents a GST model as a tool for evaluating existing hypotheses and archaeological data. Second, C. K. Maisels employs a systemic model that provides the structure for a superficial explanation of social succession. Finally, Flannery presents a systemic model that provides the structure for a deeper level of explanation than that provided by Maisels' model. These three examples are presented here to represent typical systemic approaches to archaeological research in the Near East.

3.5.01 Redman's Systemic Model

Redman (1978) is concerned with cultural change, specifically 'the Agricultural and Urban Transformations ... in the ancient Near East'. The perspective employed throughout this work is a systemic methodology (Redman, 1978: 6). His purpose is to present a framework within which current hypotheses and archaeological evidence relevant to this topic may be evaluated. In other words, Redman presents a comprehensive view of the state of archaeology in the Near East at the end of the 70's as it pertains to agricultural and urban transformations.

Redman employs the ethnographic data on modern foragers to establish the case that foraging is an effective and highly successful subsistence strategy (Redman, 1978: 90). By maintaining stable and low population levels foragers can use a mobile subsistence strategy to ensure adequate resources and 'have time for leisure and rarely suffer from the lack of food'. On the other hand, agricultural activities are labour intensive, reduce wild resources by altering the environment, produce highly variable yields, and produce resources that are subject to a number of 'storage failure' problems. In a closed system these attributes of foraging and farming would represent elements of negative feedback that should effectively suppress any changes in the foraging system that might otherwise have lead to a transition to a farming subsistence.

Another source of negative feedback is found in the nature of cereal grasses. Based on Jack Harlan's (1967) work wild cereals are characterised as often forming large nearly pure natural stands, and they can be harvested by hand, unaided by tools, to provide large amounts of food in a short period of time. Groups with access to these stands of wild cereal would not need to engage in farming.

Considering these two sets of negative feedback, which would tend to stabilise foragers within a foraging system, the important question becomes 'Why was agriculture developed at all?' (Redman, 1978: 91). Redman does not attempt to answer this question. He is only interested in setting up a framework of the elements involved in agricultural systems so that we can assess the current progress in attempting to answer this question. One model scrutinized by Redman is the Subsistence-Settlement Model.

Subsistence-Settlement Model

This model represents an 'attempt to integrate the hypothesised effects of various factors on the efficiency of different subsistence activities with the possible transitions in settlement forms' (Redman, 1978: 105). The model consists of a block diagram with 7 blocks, 14 paths of transition between the blocks, and a chart of factors divided into five general categories (see appendix A). Each factor is assigned a symbol that identifies it as facilitating a transition, impeding a transition, or being a prerequisite of a transition.

Redman has significantly simplified the model during the process of producing this formalisation. On the other hand, it is still too complicated to be adequately discussed on a factor-by-factor basis. For example, Redman does not attempt to discuss each factor, demonstrate the validity of each factor, or present the basis for selecting each factor. This is a good example of how many GST models fail to be useful due to the fact that they are too complicated.

Redman's perspective is that 'every cultural event was unique and similar events occurring at different sites had distinguishing characteristics', but 'there are regularities to be found in events that were taking place in different regions' (Redman, 1978: 106). According to this perspective his model is constructed to reflect the following statements:

> "The most important goals of an inquiry into the origins of agriculture are to discover these regularities in development and to explain the differences observed." (Redman, 1978: 106)

> "The overall value of this approach is that it focuses inquiry on anomalous categories, methods of obtaining values for the postulated effects, and objective definitions of the factors and their interrelationships."
> (Redman, 1978: 112)

This description is a closed system perspective, and it will be examined by exploring one of Redman's elements.

Redman's Closed System Approach

Redman's systemic approach is implicitly a closed system. The block diagram and the chart of factors establish this aspect of his model. The block diagram represents a fixed structure and the elements of the system, which are represented by the factors of transition, have stable forms and functions, and definable relationships that remain constant in all conditions of the system. An example of this is his statement that 'Annual fluctuations in the climate of the Near East made early farming unreliable' (Redman, 1978: 107). This is presented as an obvious deterrent to not only the transition to farming, but also to the increased reliance on farming once it had become a part of the subsistence strategy. It seems that it should be just as obvious that these annual fluctuations should have a significant impact on the foraging system too, but this is not considered. Redman also does not explore how climatic fluctuations could be the basis of positive feedback processes that could contribute to the transition to agricultural behaviours. In other words, in a closed system such fluctuations represent a negative feedback that acts to resist change to the system, but in an open system such fluctuations can lead to systemic transformations through the self-amplifying processes of positive feedback. All of the factors listed in his chart are presented as static elements that have unchanging and absolute relationships to each other and to the system.

The Potential Importance Of Redman's Work

Redman's work contains some insights that are potentially important to this research. First, in his description of cultural change Redman writes:

> "...change is a gradual cumulative phenomenon but has aspects that are more rapid and sometimes affected by the behaviour of individuals."
> (Redman, 1978: 1)

This can be interpreted to be a statement of long-term processes of change that periodically result in rapid transformations. In other words, the processes of the system remain the same, but the perceived appearance of the system periodically changes.

Second, Redman introduces a large number of parameters that may affect the system, and he states that:

> "...it is not necessary to assume that the introduction of agriculture was by means of a single pathway taken by every prehistoric group, even within the same region." (Redman, 1978: 105)

This view presents the possibility that due to the large number of parameters the system may have many different trajectories, and only some of these trajectories may lead to transformations.

Third, Redman presents agriculture as 'neither a concrete technological invention nor a single-valued discrete entity' (Redman, 1978: 91). Agriculture is presented as a series of relationships between people, land, plants, and animals. Taken with the idea that there may be more than one pathway to agriculture, this is a description of a highly dynamical system that may experience many transformations and may produce a number of configurations at any given time. In other words, the form of agriculture may vary between regions and even between adjacent areas within regions.

Fourth, Redman introduces the ideas that the people in the culture may not control cultural change, and critical behaviour may not be controlled at a conscious level. This is evident in the following statement:

> "There are several basic decisions that prehistoric people must have had to make, although they may never have recognised them as such."
> (Redman, 1978: 129)

This can be interpreted as refuting the traditional view of culture as a conscious or intentional activity. The conscious view of culture is represented in many of the decision models used to explore human behaviour.

The fifth example is important for gaining insight into the bias of the traditional view of foragers. The concept of prehistoric foragers as a monolithic or homogeneous group is often encountered in archaeological literature. Redman presents that view here in his block diagram. One block represents all prehistoric foragers, but several blocks are used to represent early agricultural groups. He presents agriculture as a number of relationships between people, land, plants, and animals, but he does not entertain the concept that many of these different relationships could have their roots in the diversity of relationships developed in prehistoric foraging groups.

Redman's model is fundamentally a closed system model, but he is trying to engage processes and topics that are fundamentally aspects of an open system. This seems to indicate an intuitive or subconscious acknowledgement on Redman's part that a closed system perspective is inadequate for this type of research.

3.5.02 Maisels' Systemic Model

Maisels approaches social succession from a systemic perspective. His system contains three factors: population growth, technological change, and social change. These factors affect each other and change together in 'pulses' (Maisels, 1990). When the system experiences 'a burst of change' the result is a new configuration that is stable in social organisation, demography, and technology. On the other hand, rapid and profound changes in any of those factors should be a reliable indication that a new social configuration is coming into being.

These factors act as constraints on each other. For example, a level of population density should not be destabilised by changes in technology, for the latter is constrained by the overarching mode of social organisation that must change to accommodate technological advances. The system can only be destabilised by failure to adapt social arrangements to ecological changes or by the inherent contradictions of the social system (Maisels, 1990: 16).

From this perspective Maisels concludes that 'there is not an *ecology* external to society', and that 'there is not, beyond hunter-gatherer society, a relationship to the ecology shared by all the members of a society' (Maisels, 1990: 17). This is an expansion of his system, but it is also an indication that the system must interact with a broader system. As the system changes, its interactions with the broader system change too.

Maisels moves deeper into his systemic model by exploring the parameters of population growth. Population levels will be constrained by three parameters: 1) least effort [or least cost], 2) least factor, and 3) effective environment. Least effort is based on Zipf's Law, and 'it simply postulates that people will preferentially seek to engage in those productive activities which result in the largest margin of return (output) per unit of input of labour' (Maisels, 1990: 17). Least factor is based on Liebig's Law, and it postulates that homeostatic populations 'are constrained at the level set by the availability of some essential factor at the time of its leanest supply or greatest requirement. Effective environment is the concept that only certain aspects of the environment are available to any population. Which aspects of the environment that may be exploited by a population is constrained by knowledge of the environment and the technology level of that population.

Maisels employs this subsystem of population thresholds in his description of the transition from foraging to farming.

> "...the process commenced with the increasing reliance by foragers upon the wild cereals available in the Near East during the early Holocene. The success of heavy cereal exploitation led to increasing sedentism, which necessitated a new pattern for the exploitation of other resources, particularly animals, and the advent of semi-permanent and then fully permanent villages which the new exploitation patterns made both possible and necessary. New patterns of subsistence allowed population expansion, hence more villages, then larger villages and, with further social change, towns." (Maisels, 1990: 40)

He warns us that this is not the simple linear model that this superficial description may be perceived to represent. Within this description Maisels envisions several transitions in social succession, and states:

> "...what did not occur was that foraging society just got blown up like a balloon to have another scale and complexity. On the contrary, we are dealing with different societies." (Maisels, 1990: 40)

This view of social succession incorporates both quantitative change and qualitative change. In other words adjustments in the system at a given level lead to quantitative changes at that level, but these changes are also involved in the processes that will cause the system to enter a transition to a new configuration. This is a continuing process of change and adjustment with chains of cause and effect relationships. In Maisels view each effect can become the cause of another set of cause-and-effect relationships.

Maisels' model is essentially a closed system, but his description of some of the processes involved presents a view of a complex and dynamical system that is potentially important. These concepts of dynamics are potentially important for illuminating the systemic transition from foraging to agriculture, but Maisels does not address them. He focuses on the closed systems contained within the model and discusses the quantitative changes that obtain to such systems, but the transition to a new system configuration is not dealt with. It is these transitions that are the essence of what any model of social succession must explicate.

One of the fundamental flaws in Maisels' model is how it relates to archaeological evidence. Maisels discusses a considerable amount of the archaeology of the Near East, and it generally fits his model. Unfortunately there tends to be terminal circularity between the model and the data. It is never possible to distinguish which came first the model or the archaeological data. In other words, the model is too general to actually be tested by the data and can be perceived as just another description of the data. For example, he suggests that the exploitation of cereal grasses tended to reduce mobility to allow for the full exploitation of this resource. The archaeological record shows both a trend toward increased cereal exploitation and increased sedentism, but it does not confirm his logical causal hypothesis. Increased sedentism could have been caused by other factors, and increased sedentism could have been merely coincidental with increased cereal exploitation or could even have preceded increased cereal exploitation.

3.5.03 Flannery's Systemic Model

Flannery (1969) employs a systemic model to explore and explain the cultural changes that lead to agriculture in the Near East. This model employs a long-term approach that begins with changes in the Upper Palaeolithic, which contribute to the Neolithic transition and the establishment of agricultural villages. The Upper Palaeolithic shift toward a trend in utilising a broader base of wild resources allows the inclusion of the cultivation of plants into a general foraging subsistence strategy. Cultivation continues as part of a mixed farming/foraging strategy for a long period of time, and in some areas it slowly increases in relative contribution to subsistence.

Flannery suggests that the next shift is characterised by caprine domestication and the expansion of trade as a way to ameliorate the erratic nature of cultivated resources. Excesses from crops in bountiful seasons could be traded for exotic goods or fed to domestic animals as a means of storage for times when crop production is not sufficient. The archaeological data in several areas show that there is an increase in trade, domestication, and cultivation, but the nature of the relationships between these three elements is arguable.

The next shift is characterised by early irrigation. This new behaviour has two fundamental effects: 1) it increases the productivity and the stability of cultivated resources, and 2) it increases the rate of reduction of wild resources. Increased productivity and stability of cultivated resources promotes dramatic population increases and social change, which includes the stratification of societies. Reduction of wild resources reduces the chances of populations returning to a mobile forager way of life.

Flannery discusses specific aspects of these shifts and suggests how they can act to promote changes that will lead to a transition to an agricultural system. Within this context he reviews some of the archaeological evidence that can be used to support this model. Flannery gives the most detail and the most explicit explanation of the shift to broad-spectrum subsistence and the shift to cultivation. This discussion will focus on these two factors.

The first factor to be discussed is the "Broad Spectrum Revolution". Flannery presents population pressure as the force behind the trend toward increasing the breadth of the subsistence strategies of forager populations. He rejects a climate change explanation of population pressure, and presents his version of Binford's (1968) equilibrium model of population pressure (Flannery, 1969: 78). In essence, this model presents the view that human population will attain equilibrium at a level far below the "starvation" level of the environment. Population pressure occurs due to high population densities in more productive areas acting as "donors" to marginal areas of production. These marginal areas will experience a level of population pressure that will tend to shift them toward broader spectrum subsistence.

Flannery suggests some examples of Upper Palaeolithic preadaptations that could have acted to facilitate the broad-spectrum shift. First, ground stone technology, which was developing in the Upper Palaeolithic, may have been used mainly for processing ochre, but it represents an existing technology that can be adapted to grain processing. In other words, ground stone technology was available as soon as people turned to cereals as a food resource.

Storage facilities represent another preadaptation that existed at a low level in the Upper Palaeolithic of the Near East. Flannery suggests that the archaeological evidence tends to show associations between broad-spectrum subsistence and storage facilities, which do not seem to be connected with any activity that is specific to ungulate hunting. Both broad-spectrum subsistence and storage facilities tend to increase with time until many sites in the period of 9,000-7,000 BC are reported to have evidence of them (Flannery, 1969: 78).

Flannery's systemic approach is apparent in two aspects of his discussion of the shift to broad-spectrum subsistence. Not only is it a systemic part of the origins of agriculture, providing the opportunity for the inclusion of cereal grasses within the subsistence strategy, but also it may 'have contributed to the development of the division of labour in Pleistocene and early post-Pleistocene era' (Flannery, 1969: 79). For example, many of the elements that were added to the subsistence strategy at this time could be easily collected by women and children, and since they include items such as snails and turtles the reliance on the high risk hunting of ungulates for essential proteins and other nutrients is reduced.

Flannery presents the beginning of cultivation as his second shift in cultural behaviour. Flannery suggests that this didn't take place in the heart of the wild grasses zone, but on the periphery in areas adjacent to the regions of greatest abundance of wild cereals. His explanation for this is based on Harlan's work with wild cereals. The Near East has vast expanses of land that have a very low diversity of vegetation. In such areas large stands of virtually pure cereal grasses probably existed in the past, as they do today. In such areas foragers could collect enough grain, in as little as three weeks, to last the rest of the year (Harlan, 1967). There is no need to cultivate cereals in such a place, but in adjacent regions foragers would have had access to cereals for planting and would be more likely to cultivate cereals to produce a similar state of abundance.

Flannery's systemic approach is evident in his view of the origins of cultivation due to the connection he makes between cereal production and sedentism. This connection is based on the logistics of each family trying to transport nearly a ton of grain. Presumably as utilisation of grain increases the large stores of grain act as a motivation to stay close to the area because the means to transport large amounts of grain did not exist. In addition to this, cultivation would tend to increase the trend toward sedentism because of the labour that must be put in at the beginning of the growing season. This ensures that the site must be occupied at least twice each year for substantial periods.

Another aspect of Flannery's systemic approach is evident in his view that agriculture decreases traditional wild resources, and it also tends to increase alternative wild resources. For example, *prosopis*, a woody perennial legume with an edible pod, matures in a different season of the year and does not compete with cereal grasses. Archaeological data from Ali Kosh demonstrates that the amount of *Prosopis* increases with the length of time that cultivation is employed. It also demonstrates that the people eat more *Prosopis* as it increases (Flannery, 1969: 88).

Discussion Of Flannery's Model

This model comes very close to attaining the level of an explanation of the origins of agriculture, but it has a few flaws. First, the explanation of the trend toward "broad spectrum" subsistence is neither convincing nor compelling. Population pressure is not sufficient to explain technological innovation (Maisels, 1990: 16 and 20). It can be employed to explain the intensification of technology that was previously only a low-level activity, but not to explain the advent of a previously unknown technology. The natural reaction to stress is an intensification of familiar behaviour. This is obvious if you consider the nature of Learning Curves. Whenever a person engages in a new behaviour the productivity of that person drops drastically. The last thing that you would do during a period of food stress would be to engage in an activity that will result in decreasing your productivity.

Second, it is not clear that the population model would actually produce the population pressure Flannery is suggesting. If you start with people only in the productive zone and have that zone donate people to the marginal zone then equilibrium will be reached where the population in the marginal zone is spending an equivalent amount of effort on subsistence as the population in the productive zone. Further population exchanges between these zones will result in an increase in subsistence effort in either zone as populations increase. Under this type of closed system regime there is no motivation to move from the high productive zone to the marginal zone, even though there is a differential population density between the two types of zone. In fact, it would be more likely that populations would move to the productive zone since the per capita increase in subsistence labour would be less for this type of population movement than for that suggested by the Binford/Flannery model (see Appendix B).

On the other hand, the addition of another parameter to their population model could make it work. For Example, the productive zones could act as donors to the marginal zones if the Near East was experiencing frequent low-level climate fluctuations that differentially affected the productive zones. In this model climatic improvements could produce greater improvement in the productivity of the productive zones and allow greater population growth. With the advent of climatic deterioration the productive zones could deteriorate at a greater rate than the marginal zones providing the motivation for populations to move to the marginal zones.

There are two problems with this adjustment to the Binford/Flannery model. First, the model becomes very complicated. Second, this adjustment eliminates the need for the Binford/Flannery model because it causes effective population pressure in both the productive and the marginal zones. Under these conditions it would be parsimonious to attribute the trend toward broad-spectrum subsistence to normal human accumulation of information, which may have been facilitated by the catalyst of fluctuating climate.

Flannery's model is potentially important because it attempts to present deeper explanations of the processes of culture change. This results in explicit discussions of relationships between the elements of the system, and it allows for the examination of the relationships between the archaeological data and the system. For example, the population/broad spectrum relationship and the cultivation/sedentism relationship may or may not be well conceived, but in either case they afford a starting place for an investigation into cultural change.

Another aspect of Flannery's model that is potentially important is the relationship between cultivation and wild resources such as *Prosopis*. This relationship reveals the complexity and dynamics of human ecology, and suggests that many elements may have participated in the transition from foraging to farming that are not evident in the later stages of the transition. This is a good example of why you cannot reverse-engineer dynamical systems. Dynamical systems have very large numbers of aspects, and some of the aspects of a system may be critical to the early stages of a transformation of the system. In many cases elements of a system that are present (and play a critical role) during the early stages of a transformation may become inconsequential or obliterated during the later stages of the transformation. This makes it nearly impossible to reconstruct their role in the transformation from evidence that is available after the transformation is complete.

3.6 CONCLUSION

The concept of culture as a system, an integrated whole, is very compelling, but GST has never been able to solve several of the fundamental problems of this perspective. Natural systems are comprised of a virtually unlimited number of elements and an unlimited number of possible interactions and relationships between these elements. On the other hand, GST was originally developed in engineering and managerial contexts, which deal exclusively with designed systems that by definition have a limited number of elements and desired interactions or relationships that fulfil a specific purpose. Natural systems (such as culture) may not have a purpose, or even worse, they may have a large number of purposes. Each researcher may see their own unique purpose for a given system, which biases how they will construct their own vision of a system.

The unique perspective problem is evident in the example of the transition to farming in Denmark. Zvelebil and Rowley-Conwy present foraging and farming as two interchangeable but mutually exclusive elements of their system for the Denmark example of the transition to farming. In contrast, foraging and farming are not mutually exclusive in their example for Finland. This demonstrates that researchers envision different systems from one example to another even for similar events.

The construction of systems and the defining of elements and interactions is a process that is fundamentally biased. Typically a system is constructed by a researcher to address an issue in the data that they have collected, and their preconceived notions of what that data means is a fundamental part of how they define and construct their system. For example, climate change and a decrease in the abundance of seals play a critical role in the explanation of the transition to farming in the Finland example presented by Zvelebil and Rowley-Conwy (1984). The system that is constructed focuses on climatic processes and avoids cultural processes (which are more difficult to establish from archaeological evidence). The authors fail to demonstrate or even argue that cultural processes could not have been responsible for the transition, and in the system they construct it is difficult to see how the cultural proposition could be addressed. For example, trading surpluses produced by farming could have been a small but significant aspect of obtaining status or prestige items. This type of mechanism in combination with many other factors could have played a significant role in the transition to farming, and the climate and seal issues could have been virtually irrelevant simultaneous events. The model presented by Zvelebil and Rowley-Conwy does not allow for this type of multiple hypothesis research.

In GST the complexity of natural systems is typically dealt with by reducing the system to a few critical interactions. For example, Coe and Flannery (1967) select "least effort" and "channelling effect" to explain the transition from foraging to farming in Guatemala. The selection of process mechanisms is as arbitrary as the selection of the elements of a system. Coe and Flannery could as easily have selected "curiosity", "accumulation of wealth", or any of a multitude of other mechanisms, but it is too difficult to deal with all the possibilities. Coe and Flannery never present any evidence to demonstrate that these two mechanisms were actually in effect during the transition to farming in Guatemala, and any attempt to do so would probably result in a circular argument between the archaeological data and the system that was constructed specifically to explain that data.

The fact that GST has been virtually abandoned in archaeological analysis is indicative of the fact that it is typically not a useful tool. Most attempts to employ the systems perspective are too simple to demonstrate any validity or utility. On the other hand, systems that are more complex become too complicated and cumbersome to be used. Thus researchers cannot demonstrate that their systems models represent an accurate picture of the processes presented. For example, Redman's model (see Appendix A) is only marginally more detailed than most simplistic models, but it is too complicated to be used as a research tool.

This chapter represents basic if simplified exploration of the application of General Systems Theory (GST) in archaeological research. The extensive use of GST can be traced to the "Great Debate" that resulted in the "New Archaeology" (Butzer, 1982). It seems that GST was thought to be a point of entry for archaeological research into a more "scientific" context. In retrospect it is easy to see how defining systems and their elements, and suggesting hypothetical mechanisms that seemed to represent the processes of interactions of elements within systems was analogous to what the "hard" sciences were doing. In recent times it is more obvious that GST just represents another methodology in which each researcher could construct their particular view, and that none of these views were any more relevant to each other than were the particularistic views that were constructed before the advent of GST in archaeology.

What I have attempted to demonstrate through the examples presented in this chapter is that GST has at least two major faults. Typically GST methodologies suffer from a fundamentally circular argument, and GST models are either too complicated to be useful or they must be simplified to the point of being irrelevant. Dynamical Systems Theory (DST), on the other hand, provides another systems perspective that retains much of the potential of GST without suffering from many of the major faults of GST. The next chapter is a discussion of how DST has been employed in archaeological research.

CHAPTER 4

COMPLEX-SYSTEMS THEORY OF CULTURE

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COMPLEX-SYSTEMS THEORY OF CULTURE

The concept of culture has been defined from many perspectives. Kroeber and Kluckhohn (1954) listed over one hundred separate definitions of culture, and in subsequent years researchers have added many more. According to Tim Ingold (1994) the culture concept is anthropology's way of registering the vast diversity of ways that humans live their lives. Ingold observes that the culture concept has defied a final definition because as anthropologists alter their perspectives on how humans live their lives they also alter their perspective on what they are studying, which ultimately alters their definitions of culture. Definitions of culture typically include the notions that they are complex, inclusive wholes, patterns of behaviour, patterns of knowledge, shared experiences of a group, humanly altered environments, symbolic activities, and material aspects of behaviour or knowledge (Keesing and Strathern, 1998). Some researchers have recognised that there are many levels to the organisation of cultures, yet we still have only one term for all of these possible distinctions. Many researchers try to link the concept of shared knowledge to the patterns of behaviour in their definitions, but some researchers (see Goodenough, 1957; 1961) see patterns of knowledge as being distinctly different from patterns of behaviour.

It is clear that this proliferation of definitions is the result of having a multitude of research perspectives that cannot be linked to any unified *explanation* of culture. The foremost goal of my research is to synthesise a general theory that explains culture. In light of this fact, I feel that it is appropriate that the definition of culture that is used within this research is one that can be generated from the Complex-Systems Theory of Culture (CSTC).

From the perspective of CSTC cultures are observable patterns of behaviour and material correlates, which include anything from ephemeral alterations to the environment to the production of objects that persist for millions of years. Culture, as a global whole, can be defined as a complex system of patterns of behaviour, which are self-organising, self-replicating, and dependent on the transmission and accumulation of information. The specifics of the organisation of this global culture are determined by the unique historical form of the information that is accumulated within each cultural entity. The fact that information flows through the entire global culture indicates that there are no absolute boundaries between cultural entities, and the more information that is transmitted between any group of cultures the fuzzier the boundaries will be. I suggest that a relatively succinct definition that might be distilled from this description of culture is:

> Culture is the complex patterns of knowledge (and the behavioural and material correlates of knowledge) that are produced and maintained by the flow and accumulation of information. These knowledge structures acquire their distinct characteristics due to the specifics of the information that is accumulated within them, and they represent self-organising, self-replicating, and self-reinforcing patterns of organisation.

From this perspective cultures are recognisable patterns of behaviour and material products of behaviour that can be investigated by analysing the information contained in the behaviour and material correlates of living groups of people or the information contained in the material correlates of behaviour that were produced by groups in the past. This statement is predicated on the fact that the explanation of culture provided by CSTC links knowledge, behaviour, and their material correlates through their integrated roles in transmitting and accumulating information.

Archaeology is still conducted within a framework that is dominated by many competing paradigms. If archaeological research is to achieve some level of unity, where all archaeological research is relevant to all archaeologists, then an adequate general theory of culture is required. In Chapter 2 I demonstrated that archaeology lacks an acceptable general theory, and that Binford's methodology for achieving a theory for archaeology does not produce the ideals of public and objective knowledge that are necessary for a unified archaeology. My research is based on the conviction that the formulation of a general theory of culture is a reasonable goal within the context of archaeological research. This chapter presents a general theory of culture that explains cultural phenomena and meets the basic criteria of providing a fully unified context for research. I refer to my theory as the "Complex-Systems Theory of Culture" (CSTC). This discussion consists of a description of the two components of CSTC, which are Implicit Learning Theory and Dynamical Systems Theory, and an explanation of how these two components constitute the underlying mechanisms of cultural phenomena.

Implicit learning theory explains human behaviour in terms of the powerful mechanisms of learning that allow humans to perceive large amounts of information and incorporate that information into their knowledge and behavioural repertoires. ILT characterises the learning process as automatic and autonomous, and presents it as a largely unconscious mechanism. The human brain has evolved to detect the covariation of events (or structure) in the stimulus environment, form abstract representations of the perceived structure, and direct the individual's behaviour to exploit the structures perceived in the environment (Reber, 1993). The implication is that humans have very little conscious control of the learning process, and that behaviours are typically employed automatically and unconsciously. These aspects of learning and behaviour have significant implications for explaining and understanding cultural phenomena. On the other hand it is not enough to understand the functions of information, knowledge, and behaviour of the individual. Cultural research requires an understanding of the interaction of individuals within a group context.

I employ Dynamical Systems Theory (DST) to explain the complex interactions of individuals that produce the patterns of behaviour that are perceived as cultures. DST is an explanation of complex systems, how they form, how they are maintained, and how they can make transitions to qualitatively different organisational states. Fundamentally complex systems are "open systems" in the sense that they depend upon a flow of matter, energy, or information (or a combination of these) to maintain a coherent existence. Cultures are assumed to be complex systems that are made up of relatively large numbers of individuals, and DST is considered to be a fundamental tool in explaining their organisation and ability to change due to internal mechanisms.

The Complex-Systems Theory Of Culture is a synthesis of these two theories (ILT and DST), and uses information flow as the fundamental aspect of explaining cultural mechanisms. Just as the effects of gravity were used to infer the existence and position of undiscovered planets; structures of information flow can be used to infer the existence of cultural entities and explain their mechanisms. Within the scope of this research project the Complex-Systems Theory Of Culture has only been developed to its first and most rudimentary level of application. This will allow it to be used to engage some archaeological data to demonstrate a fundamental application and to suggest how it could be developed to address more sophisticated applications in archaeological research. This thesis is fundamentally concerned with theory, but it is of secondary interest to note that the employment of an adequate general theory of culture, such as I have described in Chapter 2, would be the foundation of an archaeological endeavour that is just as *scientific* as any field of research, including physics.

4.1 IMPLICIT LEARNING THEORY

Open virtually any introductory psychology text to the section on learning and you will find quite a large number of models of learning. For example, in *Hilgard's Introduction To Psychology* (13th edition – Atkinson et al., 2000) learning is discussed in terms of habituation, sensitisation, classical conditioning, operant conditioning, generalised learning, discriminate learning, associative learning, insight learning, contingency learning, and even cognitive learning. As I said, all of these topics are *models* of learning. They are not *theories* of learning; at least not in the sense of the term *theory* that I have defined within this thesis. These models only describe the subjective observations of the researchers, and they offer no underlying mechanism as an *explanation* of the learning process. It is beyond the scope of this thesis to review these models of learning. Instead, I shall move directly to the only *theory* of learning that I am aware of, which Arthur Reber (1993: 4) claims can subsume all of these models within its explanatory mechanism – Implicit Learning Theory.

Implicit Learning Theory is the product of experimental psychology, and has largely been developed since the beginning of the 1970's. The perspective presented here is based fundamentally on the research conducted by Arthur Reber, which is summarised in *Implicit Learning And Tacit Knowledge* (1993). I have chosen Reber's work because he is one of the foremost researchers in this field, and his explanation of the subject matter is accessible to a broad spectrum of readers.

The traditional view in psychology has been that humans are rational and logical, and that they make decisions based on reflection and analysis (Reber, 1993: 13). This view is still a fundamental aspect of anthropological theory. Cultural theorists, such as Boyd and Richerson, characterise culture as either a consequence of environmental parameters or as a product of human learning, which is typically self directed through imitation and trial-and-error, or imposed by others through instruction and teaching. These concepts all fit into the anthropological model that operates from the perspective that humans are in control of culture, which explains why many anthropologists believe that culture is fundamentally Lamarckian. Implicit Learning Theory provides a broader perspective that suggests that all of these high level conceptual notions are based on general mechanisms that operate at a much lower level.

Reber (1993) outlines a powerful learning system that can account for a broad range of phenomena including cognitive induction, abstraction, conditioning, and associative learning. This branch of experimental psychology has produced an abundance of data that demonstrates that most (if not all) learning shares a common process – the detection of covariation between events. Implicit learning research has demonstrated that learning takes place in the absence of conscious attempts to learn and that very often learning can not be explicitly stated or even recognised by the learning individual. Implicit learning mechanisms are capable of dealing with very complex forms of information even when ambient conditions produce degraded information signals. These mechanisms appear to be evolutionarily old and robust (Reber, 1993). Implicit Learning Theory presents the perspective that humans are autonomous learners, that the capacity to learn has evolved over such a long time that the mechanisms involved in learning are common to all humans, and the mechanisms for learning are capable of capturing very complex patterns of information even in less than ideal circumstances. In other words, human knowledge is constructed by the inherent and autonomous capacities of the individual, but not superimposed on the individual by external processes.

4.1.01 The Origins Of Implicit Learning Research

Interest in implicit learning can be trace back to the middle of the 19th century. Researchers such as Helmholtz (1867), Carpenter (1874), and Ebbinghaus (1885) were aware that many complex perceptual processes functioned outside of the conscious domain (Reber, 1993). Near the middle of the 20th century interest in implicit learning was renewed as part of the research into the cognitive unconscious. The conventional view was that learning occurred as part of the rational and logical conscious milieu, and that decisions were based on reflection and analysis. Implicit learning research attracted some interest because it refuted the conventional view, and produced data that demonstrated that people do not behave in a manner that is compatible with the rational/conscious model. In complex situations that involved decision making the rational and logical elements seemed to be missing, and people did not seem to be able to explicitly state what they knew or what information they had used to solve problems or make decisions (Reber, 1993). For example Reber states:

> "In a related series of studies, Ellen Langer and her colleagues at Harvard showed that people frequently functioned in ways that were, to use their term, mindless (Langer, 1978; Langer, Blank, and Chanowitz, 1978). In situations where people appeared to be acting according to explicit and consciously developed inferences they were, in fact, drawing on implicit knowledge systems about which they had little or no awareness. Under such circumstances, people provided justifications for

their behaviour that were clearly at variance with what they had actually done."
(Reber, 1993: 14)

A broad range of research has produced evidence that people were learning implicitly and that a great deal of their behaviour was based on tacit knowledge. This research included concept formation by abstraction of common elements (Clark Hull's (1920) work on the learning of the structure of Chinese-like ideographs), complex control task capabilities (Berry, Broadbent, and colleagues experiments with controlling simulated production plants and socially interactive computer (artificial) people), and the automatic encoding of environmental information (Hasher and Zacks research on the encoding of the frequency and location of objects and events in the environment). In other words, people quite often demonstrate the ability to function knowledgeably and effectively without a conscious understanding of what they are doing or why.

4.1.02 Implicit Learning Theory Explained

Implicit learning is described by Arthur Reber as follows:

> "Implicit learning is the acquisition of knowledge that takes place largely independently of conscious attempts to learn and largely in the absence of explicit knowledge about what was acquired." (Reber, 1993: 5)

By the middle of the 1970's implicit learning was being characterised as a situation-neutral induction process whereby complex information about any stimulus environment may be acquired largely independently of the subjects' awareness of either the process of acquisition or the knowledge base ultimately acquired (Reber, 1993: 12). Implicit mechanisms are considered to be evolutionarily primitive and primary learning processes because they are unaffected by such variables as age, developmental level, IQ, and affective state, which typically have well documented affects on cognitive processes (Reber, 1993: 15).

Typically implicit learning research is conducted within a paradigm that can be described as "representational realism". There are three aspects to this view; first, the stimulus environment is conceived as more than just the physical setting for a response (see Gibson, 1966 and 1979; Garner, 1974 and 1978; and Neisser, 1976). Second, the stimulus environment is characterised as being extraordinarily rich and complex. Third, the structured patterns in the stimulus environment are described as becoming represented in the mind of the perceiver/cogniser (Reber, 1993: 58). What implicit learning research demonstrates is that when subjects are exposed to complex patterns of covariation they begin to modify their behaviour relative to the stimuli in ways that suggest a growing sensitivity to the patterns of co-occurrence and covariation (Reber, 1993: 116). This research effectively demonstrates that the pattern of information (or the structure) that is out there ends up in the minds of those experiencing the structured environment, and that when people are presented with a structured environment they exploit that structure. An implicit aspect of this view is the distinction between "mind" and "brain". The *brain* is the physical (biological) substrate that provides the capabilities for learning and memory. The *mind* is the emergent knowledge system that is constructed by the mechanisms of the brain from the experiences of the individual. This research characterises *brain* and *mind* as inseparable parts of an integrated whole, but the brain and the mind represent distinct levels of information processing.

4.1.03 Artificial Grammar Research

One of the best examples of implicit learning research is provided by Artificial Grammar experiments. In these experiments subjects are typically told that they are participating in a memory study. They are given strings of letters to memorise, and later

Learning Stimuli	Testing Stimuli	
1. PVPXVPS	*1. PTTTVPVS	*26. SVPXTVV
2. TSSXXVPS	*2. PVTVV	27. PVPXTTVV
3. TSXS	*3. TSSXXVSS	28. PTTVPXVV
4. PVV	*4. TTVV	29. TSXXTVPS
5. TSSSXXVV	5. PTTTTVPS	30. TXXTVV
6. PTVPXVV	6. PVV	31. TSSSSXS
7. TXXVPXVV	*7. PTTPS	*32. TSXXPV
8. PTTVV	8. TXXTTVPS	33. TPVV
9. TSXXTVPS	9. TSXXTTVV	*34. TXPV
10. TXXTVPS	*10. PVXPVXPX	*35. TPTXS
11. PTVPS	*11. XXSVT	36. PVPXTVPS
12. TXS	12. TSSXXTVV	*37. PTVPXVSP
13. TSXXTVV	13. TXS	38. PVPXVV
14. PVPXTVPS	*14. TXXVX	39. PTVPXVPS
15. TXXTTTVV	*15. PTTTVT	*40. SXXVPS
16. PTTTVPS	16. TSXXVPS	41. TXXVV
17. TSSSXS	17. PTTTVV	*42. PVTTTVV
18. TSSXXVV	*18. TXV	43. TSSXXVPS
19. PVPXVV	19. PTTVPS	44. PTVVVV
20. TXTVPS	20. TXXTTVV	*45. VSTXVVS
	*21. PSXS	46. TSXXVV
	*22. PTVPPPS	*47. TXXTVPT
	23. PTTTTTVV	48. PVPS
	24. TXVPS	*49. PXPVXVTT
	25. TSSXS	*50. VPXTVV

(Modified from Reber, 1993: 36)

FIGURE 4.01 – This represents an example of *learning stimuli* and *testing stimuli* for an artificial grammar research project. Note the letter strings that are marked with an asterisk are random strings, but a Markovian generator was used to provide the structured aspect of all of the other letter strings. (Modified from Reber, 1993: 36)

they are tested on their ability to recall the strings of letters. Finally, they are given new letter strings and asked to judge the "well-formedness" of the new letter strings. Figure 4.01 contains examples of the type of letter strings (sometimes referred to as artificial grammars) used in these experiments. The stimuli in Figure 4.01, it should be noted, are composed of unpronounceable sequences of letters whose order is determined by arbitrary rules. The use of arbitrary, semantic-free stimuli ensures that their underlying structures would not be familiar to the subjects prior to the research experiments. The ideal conditions for such research is to ensure that implicit learning will be examined in a way that excludes all biases due to previous learning or pre-existing knowledge (Reber, 1993: 11). Reber presents the following list of stimulus requirements:

> "1. The stimuli need to be novel, the rule system that underlies them cannot be something that is already within the subjects' sphere of knowledge – this, of course, is an important heuristic first used over a century ago by Ebbinghaus.
>
> 2. The rule system that characterises the stimulus domain needs to be complex. If subjects are able to "crack the code", as it were, by simple testing of consciously held hypotheses, implicit learning will not be seen.
>
> 3. The stimuli should be meaningless and emotionally neutral, or as devoid of meaning and affect as one can make them. The point here is to diminish extraneous aspects, particularly aspects that might have differential effects on individual subjects.
>
> 4. The stimuli should be synthetic and arbitrary. If our assumptions about implicit learning are correct, it should appear when learning about virtually any structured stimulus domain and the use of the synthetic and the arbitrary gives additional force to the argument." (Reber, 1993: 26)

These letter strings are complex and difficult to memorise (you can verify this by attempting to memorise the first four in the list).

After demonstrating that the list of letter strings is fully memorised the subjects are tested on the well-formedness of new letter strings. Figure 4.01 contains letter strings that could be used as test stimuli. The letter strings in Figure 4.01 with an asterisk are not grammatically well-formed. The grammatically well-formed letter strings in this example were generated by the Markovian model shown in Figure 4.02. Markovian generators such as the one if Figure 4.02 are capable of producing letter strings that contain highly complex patterns of information. Implicit learning experiments demonstrate that humans are very good at learning information contained in complex patterns of covariation.

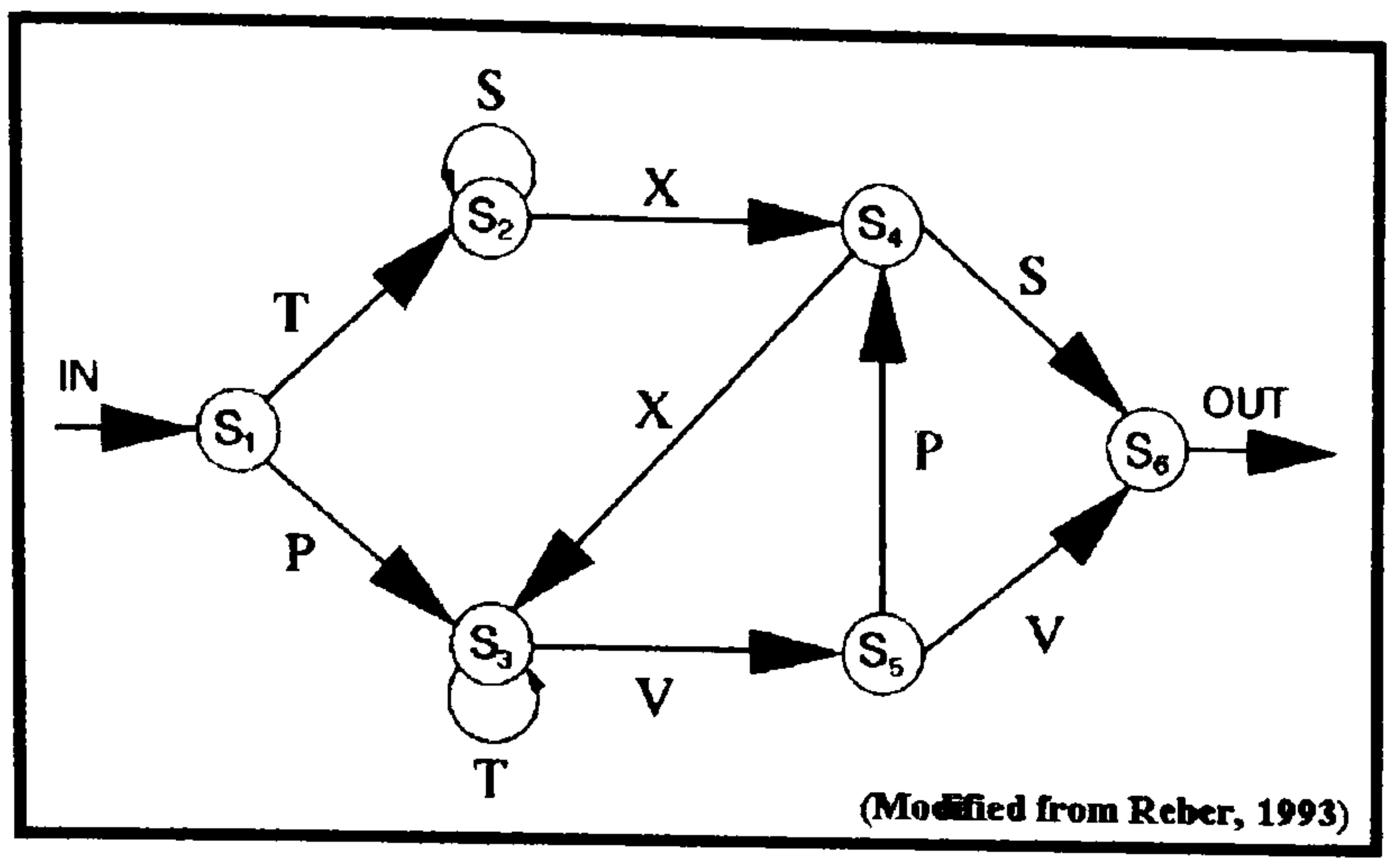


FIGURE 4.02 – This is a diagram of a Markovian generator. A letter string would be generated by starting at "IN", and at S_1 either a T or a P will start the letter string. If a T starts the string then the next letter will be an S (at S_2), and this section is a loop point so several S's could be generated. After leaving the loop at S_2, the next letter will be an X. At S4 either an X or an S will be generated, and if the letter is an S the end of the letter string is reached at S_6. (Modified from Reber, 1993)

By comparing the data from groups memorising grammatical letter strings with groups memorising random letter strings we can see two important things. First, there are at least two levels of learning, and second, the knowledge acquired is automatically used to direct behaviour in appropriate contexts to exploit the structure in the environment. Figure 4.03 demonstrates these distinct differences between the learning of grammatical strings and random strings. The mean errors of a group of subjects that are learning their first group of strings is significantly greater than the number of errors committed in memorising their second group. This pattern is common to both groups of subjects (those memorising *random strings* and those memorising *grammatically structured strings*). On subsequent sets (3 through 7) the number of errors committed is distinctly greater for those subjects memorising random strings compared to those memorising grammatically structured string sets. This is a robust finding and entails several implications. First, all of the subjects display a decrease in the number of errors committed in memorising the second set of letter strings compared to the first set. This indicates that there is a generalised "learning-to-learn" phenomenon. In other words, the task presented is new and unique and a learning curve for the task is evident in all of the subjects. Second, the improvement of subjects memorising grammatically structured strings over those memorising random strings (displayed in sets 3 through 7) indicates that the structure of the grammatical strings is being exploited in the memorisation task. Third, the ability to exploit the structure appears rather quickly. In other words, the improvement that occurs from the second to the third set indicates that learning to exploit the structure in the information occurs rapidly.

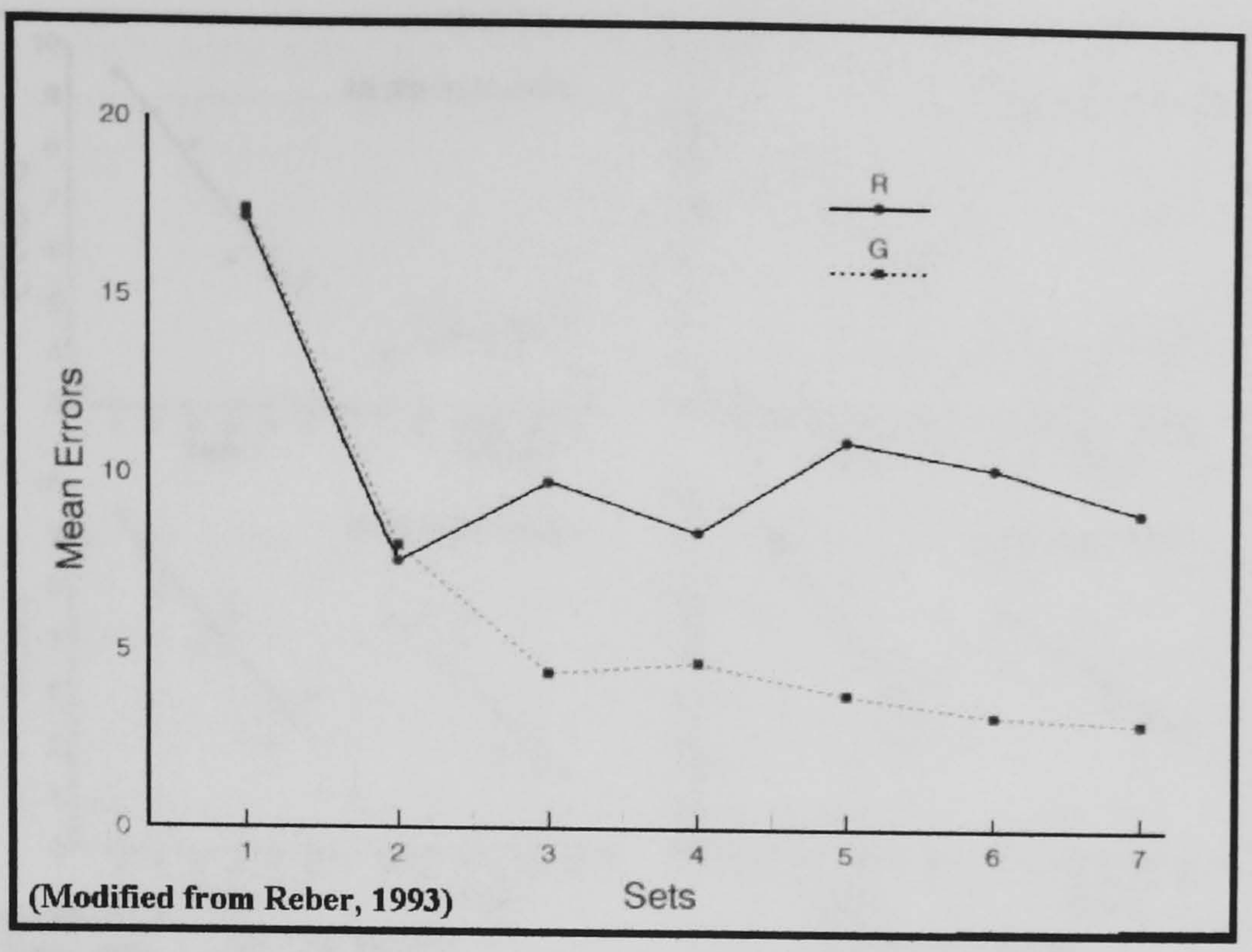


FIGURE 4.03 – This is a graph of the errors committed in memorising letter strings. The solid line represents random letter strings and the dotted line represents structured letter strings. (Modified from Reber, 1993)

Another aspect of implicit learning that has been demonstrated is the distinction between "surface" and "deep" structures. The distinction is between the letters used (the surface structure) and the patterns displayed by the letters (the deep structure). Figure 4.04 shows the results of a series of experiments where the surface structure and the deep structure were altered either individually or in combination after the initial sequence of the experiment was completed. Chart "a" represents the control group, and neither the surface structure (the symbols) nor the deep structure (the syntax of the symbols) were changed from Task1 to Task 2. Chart "b" represents the experimental group where only the symbols (surface structure) were changed from Task 1 to Task 2. Charts "c" and "d" demonstrate the decreased performance that is produced by changing the syntax or both the syntax and the symbols. This type of experiment demonstrates that the syntax that is induced is represented in an abstract form that is not dependent on the symbols used.

The knowledge that results from implicit learning has been demonstrated to be an abstract representation of the stimulus environment. This is an important discovery and has some significant implications. Our philosophical history biases our thinking to conceive of nature as a form of "rule" governed system. This leads researchers in many fields to assume that humans learn the "rules of nature" or at least some partial form of the rules by which nature operates. Implicit learning research has addressed this paradigm and has demonstrated that even when we know that a stimulus environment is

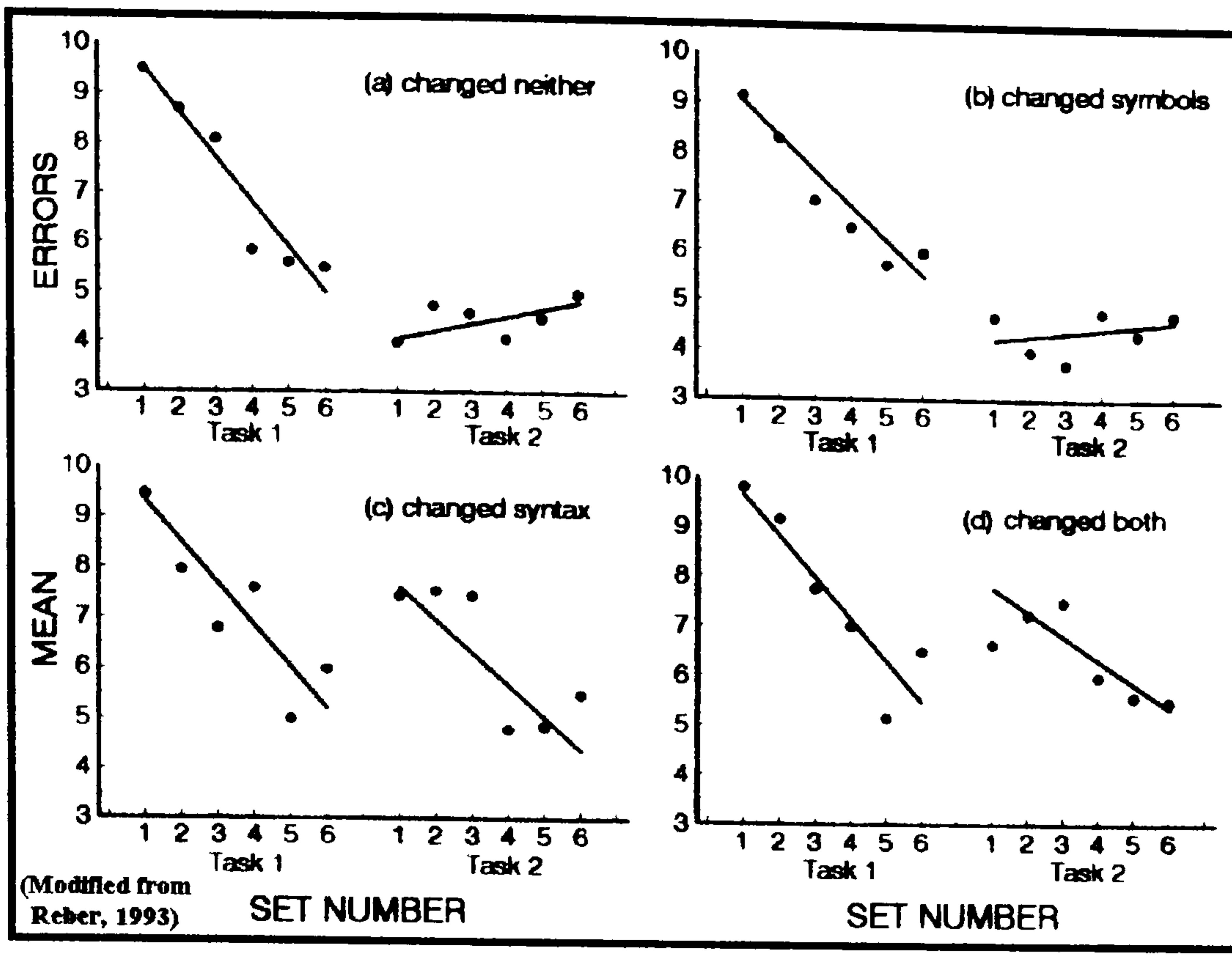


FIGURE 4.04 – This set of graphs demonstrates distinct pattern of errors that is introduced by changing the surface structure, the deep structure, or both during an artificial grammar study. (Modified from Reber, 1993)

generated by formal rules the subjects actually induce an abstraction of the pattern resulting from the rules and not the rules themselves. I will briefly discuss one of the artificial grammar experiments that demonstrates the "no rules" aspect of Implicit Learning Theory.

In the early artificial-grammar experiments after adequate exposure to the grammar generated by the formal Markovian rules, the subjects demonstrated the ability to behave effectively relative to these grammars. When this was evident in the subjects behaviour the researchers assumed that the subjects had come to "know the rules" that generated the structured stimuli. Later experiments falsified this assumption by exposing subjects to the formal rules of the grammar at different stages of the learning process. If the subjects were actually learning the "rules" of the grammar then the farther along in the learning process they were the more comprehensible the formal rules should be when the subjects were exposed to them. The subjects were exposed to the formal rules of the grammar by showing them the Markovian device (see Figure 4.02) and demonstrating how it generated the grammatical letter strings. The results of this exposure demonstrated that the farther along the subjects were in the learning process the more "foreign" the rules seemed to be. Also, the farther the subjects were into the learning process the more this exposure tended to interfere with their performance. Reber explains this in the following:

"...subjects were using complex coding systems based on the patterns of covariations between letters, which had become formed into two- and three-letter groups or chunks to represent the stimuli. The sudden "insight" that the stimuli they had been working with were "in reality" sequences of letters based on an underlying finite-state system was not only of little or no value, it actually tended to depress performance below that of subjects who had had less experience with the stimulus display prior to the formal explication of structure."

(Reber, 1993: 113)

In other words, even when we can demonstrate that the nature of a stimulus environment is generated by "rules" the nature of the information that is induced by those subjected to that environment is not the rules that generated it but some abstraction of the patterns in the stimuli that is produced by those rules.

4.1.04 Additional Experimental Methods

In addition to artificial grammars a number of other experimental formats have produced corroborating evidence to support Implicit Learning Theory. Probability Learning Studies constitutes a significant contribution to this research. Figure 4.05 presents a graphical representation of the results from a Probability Learning Study. The event probabilities were displayed to the subjects at a rate of two per second, and after sufficient experience with the events the subjects were able to predict the peaks and valleys of the events (as is shown in Figure 4.05). The events are presented in the form of rapidly flashing lights that appear more as a *density* than as individual events.

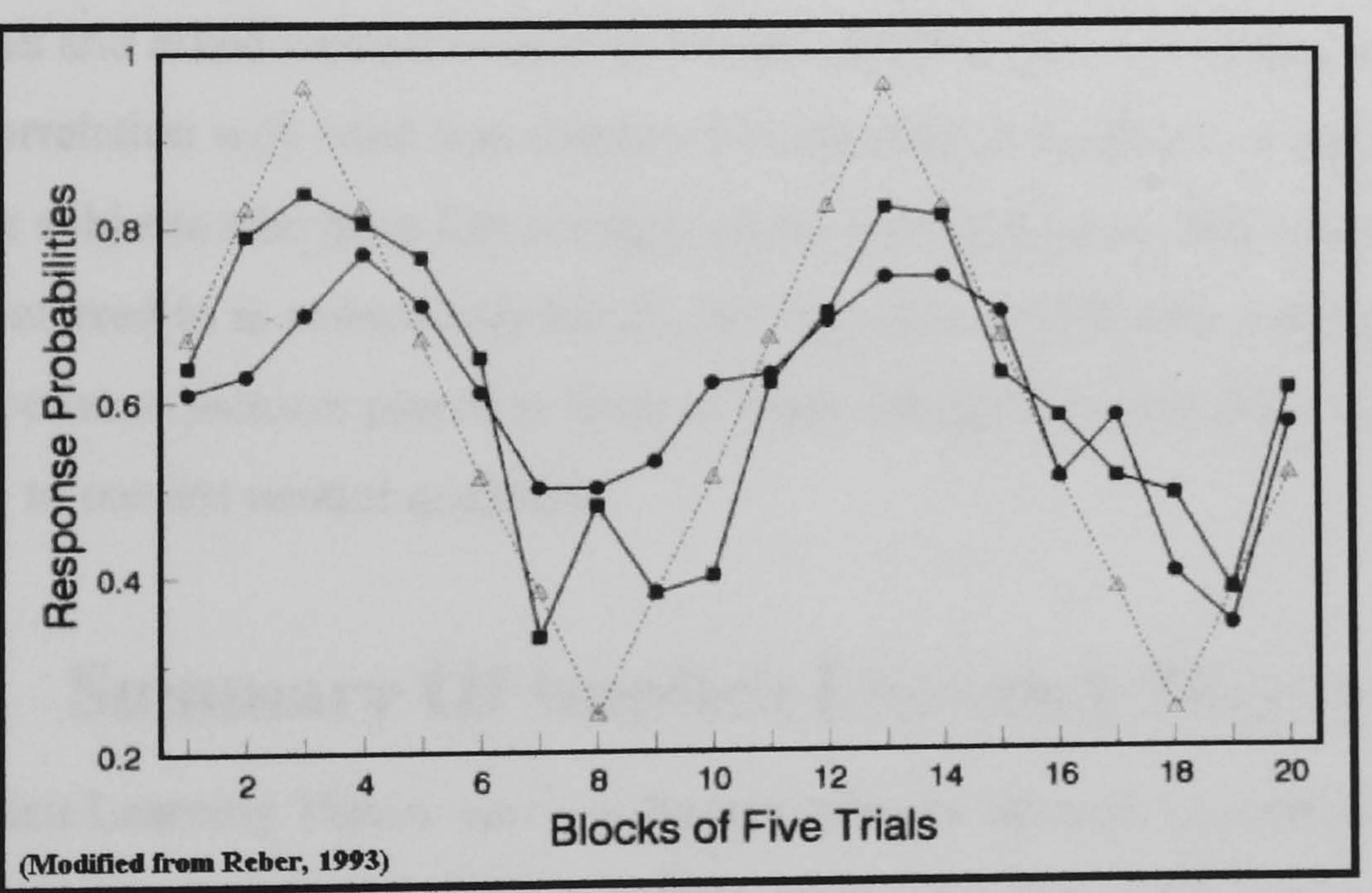


FIGURE 4.05 – This graph represents the typical results of a probability study. The dotted line (with triangles) represents the input stimulus, and the solid lines represent the predictions of two subjects who were experienced with the stimulus. (Modified from Reber, 1993)

Research subjects learned to respond appropriately to probability stimuli without being able to state explicitly what they are doing or why.

Another experimental format is displayed by Control-Task Studies. The two that are discussed by Reber are simulated production tasks and simulated social interaction tasks. In these studies the subjects are presented with a *manufacturing situation* or a *computer person*. These simulations are complex rule systems that must be constantly adjusted to maintain the desired result. Again, subjects attain a sufficient level of experience and demonstrate a high level of proficiency in these tasks without being able to explicitly explain what they are doing or why it works.

A third experimental format is in the form of Matrix-Scanning Studies. In one of these studies subjects were exposed to a complex matrix of numbers arranged in four quadrants on a computer screen. The numbers changed locations per a complex rule system and the task of the subject was to indicate the location of a specified target number as rapidly as they could as the number changed location. After sufficient experience with shifting numbers their response time reduced compared to control subjects that had randomly generated number matrixes. This indicates that the subjects with the structured matrixes were anticipating the next location of the target number, which was allowing them to respond more quickly.

One of the most striking experiments, in my opinion, involved the degradation of visual input. A drawing of a unique object was degraded (by blurring or splattering) until it was unrecognisable to conscious perception. Subjects were then exposed to these pictures and asked context neutral questions and their answers demonstrated a statistical correlation with what was displayed in the degraded picture. A variation on this involves subjects who have lost primary visual sensation (a condition that is commonly referred to as *consciously blind*), but they also demonstrate a statistical correlation between pictures placed in front of them (which they state they can not see) and answers to context neutral questions.

4.1.05 Summary Of Implicit Learning Theory

Implicit Learning Theory explains human learning through a powerful mechanism of induction that constructs abstract representations of the patterned stimulus input and incorporates them into the human mind. This mechanism is characterised as the induction of covariation of events in the stimulus information. Implicit learning is common to all humans, and it can be used to explain virtually all known learning phenomena. The learning process is apparently an "unconscious" process in the sense that it is not dependent on conscious mechanisms, is not consciously controlled, and the learner is typically not consciously aware of the learning process. Implicit learning is an automatic process, and the deployment of the knowledge acquired by learning is also an automatic process that is not controlled by conscious mechanisms. Implicit Learning Theory is important because it demonstrates that the stimulus environment is rich with information (far richer than is typically perceived from a conscious perspective), and that humans are equipped with a universal learning mechanism that affords access to this rich and complex stimulus environment.

People apparently induce abstract representations of the frequently complex patterns of covariation in the environment, and automatically alter their behaviour to make use of this knowledge. ILT explains human behaviour based on a universal mechanism of learning. The individual is exposed to information in the environment, constructs knowledge based on that information, and adds information to the environment through their behaviours, which are based on their knowledge. Human behaviour, which produces material culture, contains clues to the knowledge and information that is used to produce it. ILT provides the means for linking information to knowledge, knowledge to behaviour, and behaviour to the material components of culture. From this perspective information can be inferred from the material components of culture, and material culture can provide a reliable foundation for reconstructing aspects of knowledge and behaviour.

4.2 DYNAMICAL SYSTEMS THEORY

Cultures (or societies) are often described as being complex or as being complex systems (Gellner, 1988). This has frequently been used to justify the lack of progress in explaining what culture is and how it works. Cultural research may involve relationships that are more complex than physics, chemistry, or biology, but with the advent of DST (Dynamical Systems Theory) this difficulty should be reduced because DST provides the knowledge necessary for understanding and explaining complex systems.

Complexity can be described or defined in any number of ways, but there is only one scientific theory that constitutes an *explanation* of complexity. It is my contention that an understanding of Dynamical Systems Theory can provide useful insights that are relevant to cultural research, and that it is reasonable to include DST as one of the universal mechanisms for explaining culture and cultural evolution. Complex-Systems Theory Of Culture incorporates DST as one of its fundamental components.

One of the most difficult challenges of cultural research is how to describe its complexity, and at the same time to explain how culture transforms from less complex forms to more complex forms. Very often anthropologists have avoided this problem by assuming that increases in cultural complexity were predicated on either a reorganisation of the biological substrate or an increase in biological complexity. This doesn't answer the question; it merely removes it from the realm of anthropology and places it in biology. My perspective of culture includes processes that lead to increased complexity at both the biological and the cultural level. On the other hand, I am suggesting that anthropologists can leave biological complexity to biologists, that we can focus our investigations on complexity that arises from cultural processes, and that DST will be a critical tool for facilitating those investigations.

4.2.01 Dynamical Systems Explained

A *Dynamical System* is a difficult concept to define. This area of research is still very new, and many of the fundamental concepts have not yet been standardised. This research is often referred to as Chaos Theory, but I will avoid this terminology because it is fraught with misconceptions and is often too confusing to be useful. My usage of the term "dynamical" will be restricted to a special type of system. To understand this I will employ a concrete example – a wind-up clock (Figure 4.06). This clock is a designed system, and its parts move therefore it is also a dynamic system. The clock viewed as a whole is characterised by a simple but useful state – the constant and uniform movement of the two hands to indicate the passage of minutes and hours. As long as the spring is periodically wound the clock will continue to exhibit its characteristic system state (a uniform linear measurement), and the clock can be described as a *closed system.* Closed systems are not dependent on a steady flow of material, energy, or information from external sources.

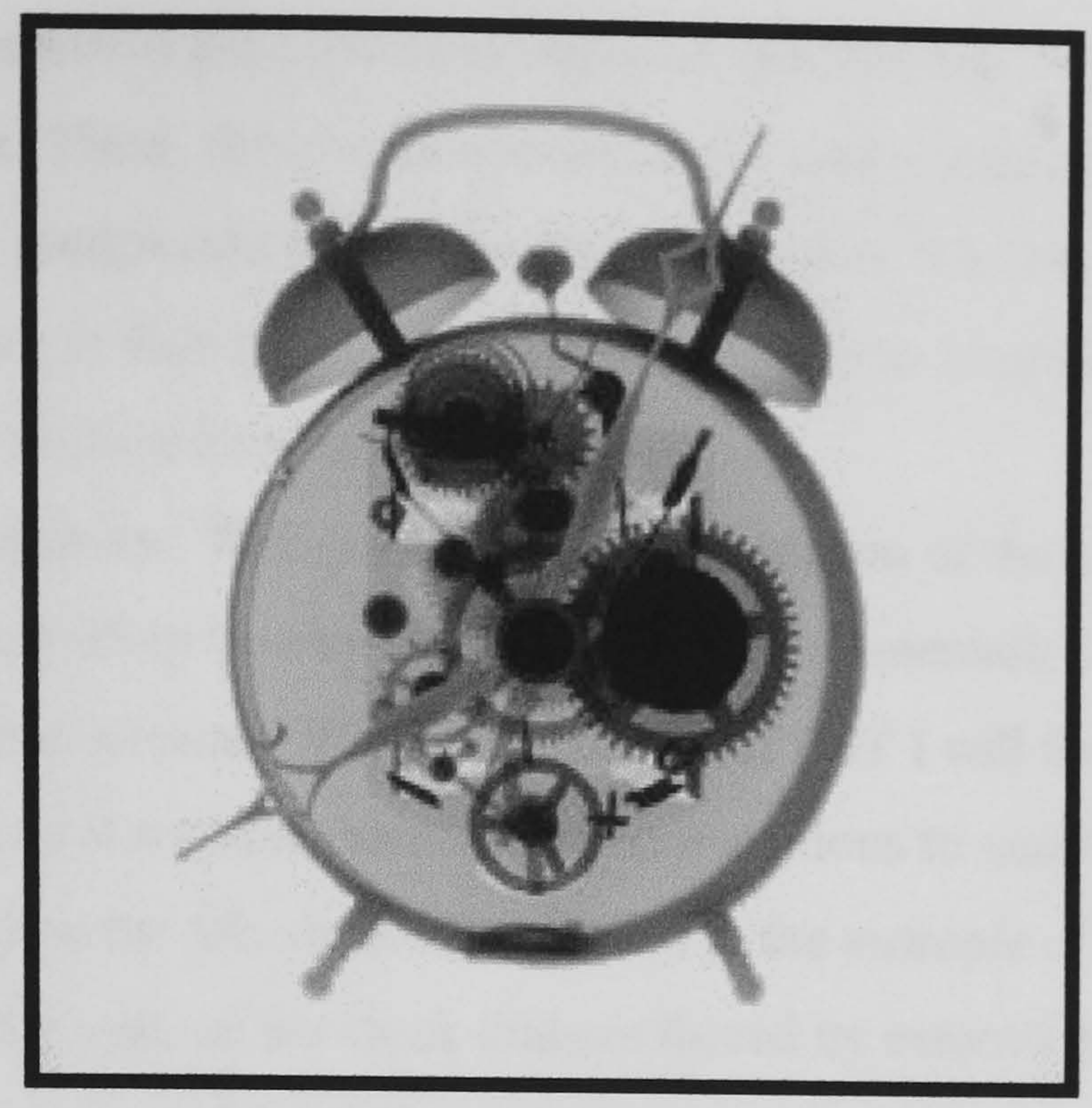


FIGURE 4.06 – This photograph demonstrates that a clock is an integrated system and not just a collection of objects. This is a classic example of a designed system that is also a closed system.

A dynamical system, on the other hand, can potentially display qualitative changes in system states. For example, if we were to take our clock on board a small ship and sail the ship out onto the ocean we would introduce our closed system to an environment in which it could potentially experience an open-system state. If the weather is calm so that there are no waves then the clock will function just as it does on land (producing a uniform motion). Now, if our ship were to sail into heavier weather, where the waves became increasingly sever, the clock would eventually experience a transition from uniform (and predictable) motion to non-uniform motion. Under the influence of moderately large waves the clock could be described as an open system, and its state would qualitatively change to non-uniform motion that is forced by external (environmental) parameters. The effect is that the clock would speed-up and slow-down as its momentum changed and the output would be qualitatively different from that of a similar clock that is operating in an environment with a constant momentum. This example demonstrates a distinction between a dynamic system and a dynamical system. A dynamic system is any system that displays motion. On the other hand, a dynamical system is any system that can display qualitative transformations in its typical pattern of motion.

This example demonstrates several important aspects of systems. First, a system is always defined by a researcher (as are the components of a system), and the status of a system is always dependent on the context of the system as defined by a researcher.

Second, all natural systems are open systems due to the fact that they are all part of other larger systems. Third, dynamical systems tend to have at least one state that has an unpredictable or unexpected behaviour or configuration. The most important feature of dynamical systems is their potential to exhibit a transition to at least one other state that is qualitatively distinct from an index state.

Dynamical Systems Theory provides an explanation of the transition to qualitatively different states by a system, and this is fundamentally important to the explanation of cultural systems. Within the context of DST I will focus on the internal parameters of systems that cause them to exhibit transitions to qualitatively different states. The justification for this should be obvious in the example of the clock provided above. Changes to the state of the clock that are forced by external parameters provide little, if any, insights into understanding the clock or formulating an explanation of clock behaviour. Similarly, studying the changes in cultures that are forced by external components (biological or environmental) will contribute very little to our understanding of cultural mechanisms. Therefore, my research will focus on the inherent aspects of dynamical systems that are responsible for their properties of organisation and transformation.

Dynamical systems are distinct from the other categories of systems in that the structure of the system is not fixed and the elements do not maintain constant relationships. The structure of the system is organised by processes of interaction between the elements, and as these interactions change in relationship to each other the structure of the system will periodically change.

Dynamical systems display a broad range of behaviour. Many systems will display relatively long periods of static equilibrium, linear change, or periodically repetitious behaviour before producing their characteristic transformations. The property of dynamical systems that most investigators find interesting is their ability to unexpectedly produce periods of rapid and discontinuous change that often results in a transformation of the system into a new and unpredictable state or configuration. It is this characteristic behaviour that separates dynamical systems from static and dynamic systems, and it is responsible for the traditional view that they tend to be chaotic. The ensuing discussion will begin will the distinction between open and closed systems.

4.2.02 Open Systems

One of the most fundamental aspects of dynamical systems is that they are open systems. Open systems constitute a class of systems that are formed and maintained in a regime that is characterised by a constant exchange with its environment. This exchange is typically expressed as a flow through the system, where the system exchanges matter, energy, or information (or any combination of these) with the environment within which it exists. In other words, these systems exist within a context that is a source for matter, energy, or information; they receive this input from the environment; make some alterations to it; and then release it back into the environment. This constitutes a dissipative system, which means that the system is involved in non-reversible processes that have evolutionary significance (Prigogine, 1997; Kauffman, 1993). DST was originally most significantly formulated by research into the flow dynamics of fluids, and this is where I will begin.

The flow that maintains an open system is also a fundamental aspect of its complexity. Since dynamical systems achieve their greatest complexity when they are functioning far from equilibrium (Prigogine, 1997) it seems reasonable to use an equilibrium state as a reference condition. A state of equilibrium represents the lowest level of complexity for any dynamical system, but it must be remembered that all

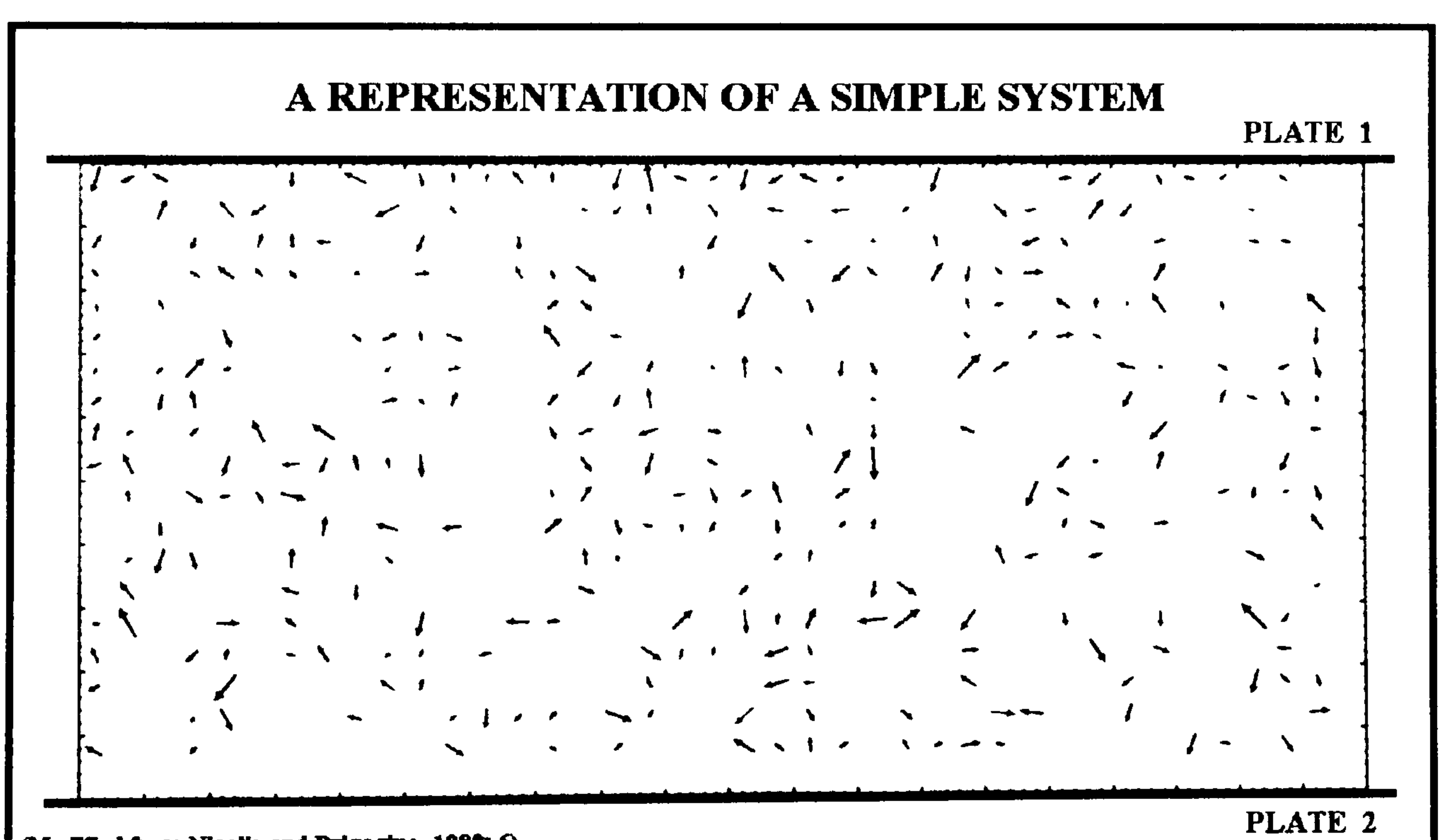


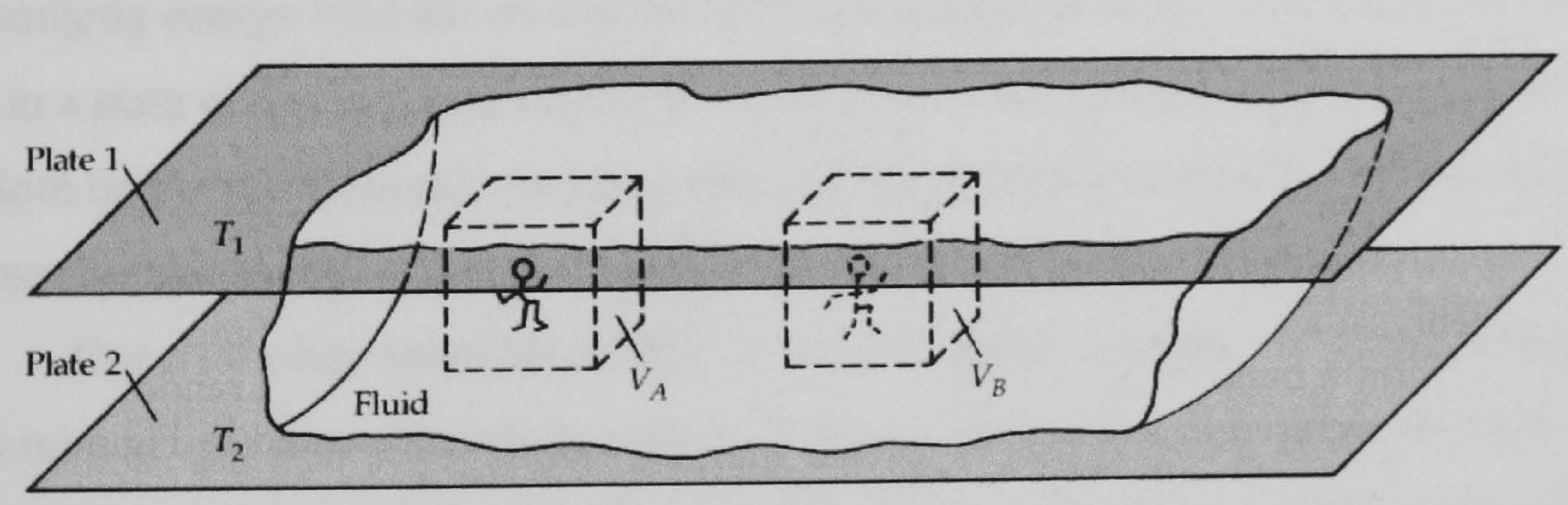
FIGURE 4.07 – This diagram is a representation of a homogeneous fluid that is at thermal equilibrium. Each arrow represents the trajectory and velocity (energy level) of an individual molecule. This is an example of a simple system because the molecules are moving randomly so there is no structure to the system. (Modified from Nicolis and Prigogine, 1989: 6)

equilibrium states represent a *local equilibrium state*. In other words, no system ever achieves an absolute equilibrium, and all equilibrium states are described with respect to their local contexts of dynamics.

Gregoire Nicolis and Ilya Prigogine were two of the first researchers to make significant progress in describing and explaining transitions in simple systems that lead to complexity and then to chaos. The first step is to understand what is meant by simplicity. In *Exploring Complexity* (Nicolis and Prigogine, 1989) a homogeneous fluid that has attained thermal equilibrium is used as an example of a simple system. Figure 4.07 is a diagram of a relatively thin layer of fluid that is located between two plates and is at a local thermal equilibrium. This can be described as *static equilibrium*, which is reached when no new energy is added to the system and the system changes energy level until its temperature attains a constant value that matches the environment. *Dynamic equilibrium* in an open system would be reached when a constant amount of energy is added to the system, but the energy level of the system remains constant because the energy lost to the environment equals the input energy. In nature all systems are open systems, and they exchange energy with the broader environment within which they exist.

The motion of the molecules in this fluid is described as random, which means that a global description of the fluid would require a description of every molecule in the fluid (due to the fact that each molecule could have a unique trajectory). A homogeneous environment at equilibrium contains no information. In this state any

REPRESENTATION OF A HOMOGENOUS SYSTEM AT THERMAL EQUILIBRIUM



(Modified from Nicolis and Prigogine, 1989: 9)

FIGURE 4.08 – This drawing depicts the condition where an observer cannot distinguish between being in location V_A and V_B. (Modified from Nicolis and Prigogine, 1989: 9)

arbitrarily chosen volume of fluid is indistinguishable from any other volume of equal size.

Another way of looking at this is presented in Figure 4.08. At equilibrium the fluid represents a system that has no structure to it because it consists of a number of volumes of indistinguishable randomly moving molecules. In other words, a fluid that is at thermal equilibrium contains no information that would allow an internal observer to identify their location within the fluid. For example, the observer in volume V_A in Figure 4.08 cannot tell if they are in volume V_A or V_B because there is no pattern to the motion of the molecules that would provide a structure for specifying location, space, or time. All homogeneous systems at equilibrium are described as simple. In other words, a simple system can be dynamic (its parts can move) as is seen with the molecular motion in the fluid, but random motion is unstructured in the sense that it does not move (or behave) in any consistent pattern. The transition from a homogeneous condition to a structured condition is the fundamental distinction between a simple system and a complex system. DST also provides an insight into evaluating the relative complexity of a system that is based on how far from equilibrium the system has moved.

A fluid described as a system such as is presented above is frequently referred to as a *many bodied system* because the system consists of many similar elements, which in this case refers to the molecules of the fluid. An understanding of the dynamics of the system requires some knowledge of the inherent properties of the *bodies* (or elements) of the system. In this case one of the important properties of the elements of the system is the fact that the molecules of the fluid can absorb energy from the environment. Actually many researchers would point out that the fluid is always exchanging energy with the environment (at any temperature above absolute zero), but that in a state of thermal equilibrium the exchange is non-directional (balanced) and random (static equilibrium). As the system is forced away from static equilibrium by excess thermal energy in the environment some interesting things occur.

One of the key concepts of DST is that complexity (structure) is produced (and maintained) by a flow through the system. We can demonstrate this using the fluid in Figure 4.07. In its simplest condition (thermal equilibrium) the plates that contain the fluid and the fluid are all at the same temperature. If we were to increase the temperature of the bottom plate then a flow of energy would be introduced to the system, which would transform it from a *closed* system to an *open* system. At low thermal differentials the energy would be passed from the bottom plate to the top plate by the process of conduction. In other words each molecule would pass on some of its energy to those above it, but there would be no net movement of molecules from the lower levels of the fluid into the higher levels of the fluid. One of two conditions could pertain. First the energy from the bottom plate could be conducted to the top plate until the system once again reached thermal equilibrium, or second, the top plate could dissipate the energy into the environment and a dynamic equilibrium would be reached with a continual conductive flow of thermal energy through the system. The second condition is the one that is of interest to research into Dynamical Systems because it is an *open system*, and, therefore, the one that is to be explored here.

4.2.03 Complexity: The Emergence Of Structure

We can force the *fluid system* away from a state of equilibrium by heating the bottom plate (Plate 2 in Figure 4.07); then the fluid system is exchanging significant amounts of energy with its environment. In this instance the bottom plate receives thermal energy from the environment, the energy is transmitted through the fluid, and is dissipated to the environment from the top plate. At low levels of energy flow the system remains very close to its original equilibrium state and the energy flow is characterised by conduction. If the flow of thermal energy is gradually increased a critical level will be reached where the system will make a rapid qualitative change to a new state, which is described as convective flow (see Figure 4.09). The Benard cells diagrammed in Figure 4.09 constitute patterned or structured behaviour that is an example of the emergent properties of dissipative systems and is sometimes referred to as a *coherent collective* (Auyang, 1998). The fluid system now contains information, and an observer placed in the fluid would have some clues as to location, time, and space.

Benard Cells are frequently referred to as "structures", but it might be more realistic to acknowledge that they are coherent patterns of collective behaviour (Nicolis and Prigogine, 1977). In other words a Benard cell has no static structural component, and it is maintained by a flow of thermal energy. If we decrease the flow of thermal energy below its critical level the Benard cells cease to exist. Also, if we were to increase the thermal energy flow through the system eventually another critical flow level would be reached. At this higher level of energy flow the structure of the Benard Cells will break down and the flow of the fluid will become chaotic and unpredictable.

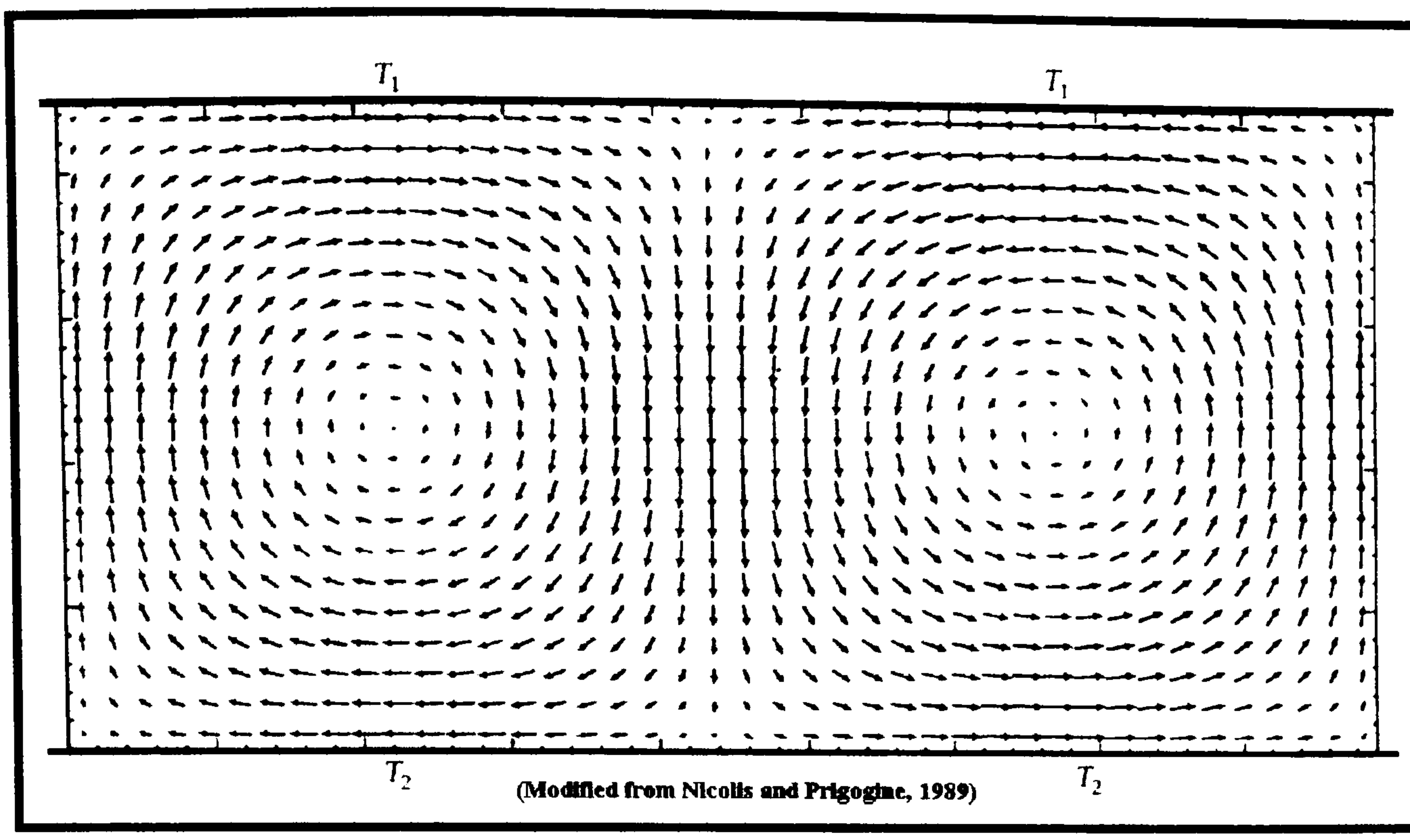


FIGURE 4.09 – This diagram is a representation of the trajectories and velocities of molecules of fluid that have self-organised into Benard Cells. (Modified from Nicolis and Prigogine, 1989)

Chaotic flow within fluids is called turbulence. This example demonstrates that a system that is comprised of elements as simple as the molecules of a homogeneous fluid can make at least two fundamental transitions to qualitatively distinct states under the effects of a dissipative flow of thermal energy. From an information perspective the system can be described as making a transition from a state of equilibrium where it contains little or no information, to a structured state that contains significant amounts of information, to a chaotic state that contains so much information that it seems impossible to make any sense of this state.

This system can be forced through two transitions, first from simplicity to structured complexity and then from structured complexity to chaotic complexity. The example of a fluid is simplistic at best because homogeneous fluids only have a very few degrees of freedom, but it does illustrate some of the fundamental aspects of dynamical systems. First, these systems can make transitions from one state to a qualitatively distinct state. Second, these systems are characterised by a relatively large number of similar elements that have a distinct set of characteristics. Third, the dynamical nature of the system is largely due to the dissipative nature of the interaction between the system and its environment (this means it is an open system). Fourth, the global nature of the system is largely due to the typical behaviour of its elements and how they interact with each other at the local level. Fifth, the global nature of the system is qualitatively distinct from the nature of its individual elements. Complexity is achieved in a system through the transition from an unstructured state to a structured state. This type of qualitative transition is the fundamental aspect of a dynamical system, and these transitions are based on the fact that these systems are open and dissipative. Finally, the transition from a simple system to a complex (structured) system results in the system retaining a portion of the flow through the system. In the example of the Benard Cells the cells provide a convective structure that is more efficient for transmitting energy through the system than conduction is. On the other hand, energy is required to maintain the structure of the Benard Cell. The structure in the system produces a more efficient flow and captures a portion of the flow. As a system becomes more complex (increases its structural diversity) it will increase its ability to capture a portion of the flow through the system. Increasing the flow through the system and increasing the amount of flow that is captured moves the system farther and farther from equilibrium. The systems that display the most attributes of complexity are those that function far from equilibrium (Prigogine and Stengers, 1984; Prigogine, 1988). The transitions to increased complexity are typically discussed in terms of emergence and self-organisation, and these will be the next topics of this discussion.

4.2.04 Emergence

One of the fundamental aspects of dynamical systems is that they can display more than one qualitatively distinct state. This is often referred to as *Emergence*. In the example of the fluid, presented above, the Benard cells are an emergent property that is constituted and maintained by the flow of energy through the system. In a dynamical system emergence is the occurrence of a behaviour of the system that is qualitatively distinct from the behaviour displayed at the level of the constituent elements of the system. Benard cells are also an example of self-organisation within a dynamical system. As a system organises into a structured pattern of behaviour it displays more complex behaviour, but it also becomes easier to describe. For example, in the homogeneous state a description of the fluid involves a large number of statements about individual molecules and their motion. After the transition to the Benard cells, the fluid attains a state that is characterised by more complex dynamics, but it can be described as a number of cell pairs. In fact a description of any two adjacent cells will be sufficient for specifying the behaviour of the entire system.

The Benard cells represent an increase in complexity because the dynamics of the system are operating on two distinct levels instead of one. The individual molecules of the fluid are still displaying the dynamics that were evident in the equilibrium state, but in the convective state the combined dynamics of the molecules takes on a higher order structured behaviour. Another example of this is the phase states of water. A single molecule of water (two hydrogen atoms and one oxygen atom) has a number of distinct properties, but no single molecule of water is a gas, a liquid, or a solid. It requires the interaction of a large number of molecules of water to display these phase states, and which phase the molecules will display is determined by a number of parameters (pressure, temperature, volume…). One of the defining aspects of emergent properties is that they cannot be predicted from the properties of an individual element (Auyang, 1998) – the whole is more than the sum of the parts.

As the number of parameters of the system increases the number of emergent properties that the system can display will increase. For example, the earth's atmosphere is superficially analogous to the fluid example presented above. The lower plate is the surface of the earth and the upper plate is outer space. The sun warms the surface of the earth, and that heat is transferred to the atmosphere. A series of Benard cells encompass the earth, and the strongest pair is located over the equator and aligned with the equator (the area of highest energy transfer). As warm moist air rises from the equator it is split into two cells, one that circulates to the north and one that circulates to the south of the equator. As the air rises it cools and gives off its water vapour, which forms other structures in the atmosphere (clouds, fog, rain, sleet, hail, snow…). At about 30 degrees north and south of the equator the cool dry air falls to the earth and travels back to the equator (some of this air may also become involved in the next cell that circulates farther to the north or south of the equatorial cells). This is one of the reasons that most of the great deserts of the world are found around 30 degrees north and south of the equator. The cool dry air absorbs moisture as it falls towards the ground and transports the moisture back towards the equator. The earth's atmosphere is not a homogeneous fluid. The atmosphere contains many types of gas, dust, water vapour, and many forms of free chemicals and other particles. There are quite a large number of self-organising structures that have been identified in this *fluid* system. In fact one form of weather prediction is based on identifying these structures and trying to predict their formation and persistence, not to mention their track across the landscape (Lorenz, 1993). All of the patterns of behaviour found in the atmosphere are caused and maintained by the flow of solar energy. Wind, clouds, lightning, etc. take on extremely complex forms because of the large number of parameters of the system. For example, the surface of the earth is not flat, is not heated uniformly, nor heated consistently. The flow of energy fluctuates geographically, daily, seasonally and even yearly. This fluctuation and variation introduces a large number of parameters that effect the size, shape, and persistence of the common structures in the atmosphere that we recognise as patterns of weather. The structures that are discussed within the context of DST are not only emergent properties of an open system they are also self-organising entities.

4.2.05 Self-Organisation

The systems that are important to archaeological research are the ones that are to some degree self-organising and self-regulating. These systems can be described as being capable of evolving (Kauffman, 1993). This has two aspects; first, self-organising systems are organised as a result of a distributed network of interaction, and not as a result of a 'centralised organising force'. In other words, if you disassemble the system you will not discover an organising element or sub-system. Second, self-organisation implies that the mechanisms responsible for the organisation of the system, and, therefore, any transformations to the system are internal to the system and not external to the system. For example, ecological explanations of cultural organisation rely on mechanisms that are inherently external to cultural systems, and, therefore, do not constitute explanations of cultural transformations. They may constitute explanations of ecological systems that contain a cultural component, but they represent a qualitatively different perspective.

In the example of emergent structures in a fluid (Figure 4.09) the Benard cells are self-organising entities. There is no external organising entity that forms the fluid into Benard cells, and there is no separate internal organising entity that produces an individual Benard cell. In fact a single Benard cell cannot exist because the cells are a product of the global behaviour of the system. In other words, the organisation of the Benard cell is achieved through the interaction of all of the elements that comprise the system.

One of the important aspects of self-organisation is that the emergent structure contracts the dynamics of the system into a small area. For example, before the Benard cells form the system is a vast quantity of uniquely moving molecules. After the Benard cells form the system can be discussed from the perspective of one cell (a much-reduced quantity). This is useful because as the complexity of systems increases to hundreds, thousands, or even more parameters, the solutions to self-organising systems tend to be on the order of two to three dimensions (Kauffman, 1993). This means that generally the solutions to these systems will be grouped together in some relatively tiny area of the phase-state space. Self-organisation is an important aspect of many dynamical systems (Kauffman, 1993) because at a global level they are patterned and partially predictable. The characteristic structures that form as part of the self-organising processes are often referred to as *attractors,* and this is the next topic to be discussed.

4.2.06 Attractors

One way that emergence and self-organisation have been discussed is through the concept of an "attractor". An *attractor* "... is a set of points of states in state space to which trajectories within some volume of state space converge asymptotically over time." (Kauffman, 1993: 177). Attractors 'box' the behaviour of the system into small parts of its state space, or space of possibilities. This is important because once you have found a portion of the system you no longer need to explore the entire phase space that the system could occupy (Kauffman, 1993). You need only look near where you have found part of the system. Thus, 'attractors' is most of what self-organisation is about (Kauffman, 1993). For example, an attractor can be represented by a ball inside a bowl. All of the trajectories for the ball inside the bowl result in the ball coming to rest at the bottom of the bowl. The bowl can be seen as the *basin of attraction* for the attractor. The bottom of the bowl where the ball comes to rest is the attractor (the flatter the bottom is the more points there are within the attractor). The wider the bowl is, the farther away from the attractor the ball can be moved and still have a trajectory that results in the ball coming to rest at the attractor at the bottom of the bowl. The deeper the bowl is the greater the energy the ball can have and still remain inside the bowl, which results in the ball coming to rest at the attractor. The size and shape of the basin of attraction determines the stability of the attractor.

Attractors represent one of the more useful aspects of dynamical systems. The fact that a specific system tends to self-organise into a particular attractor (or group of attractors) means that it is possible to make some predictions about very complex systems. One of the simplest attractors is a *point attractor*. Figure 4.10 is an illustration of a system that has a trajectory that moves the system towards a specific state that can

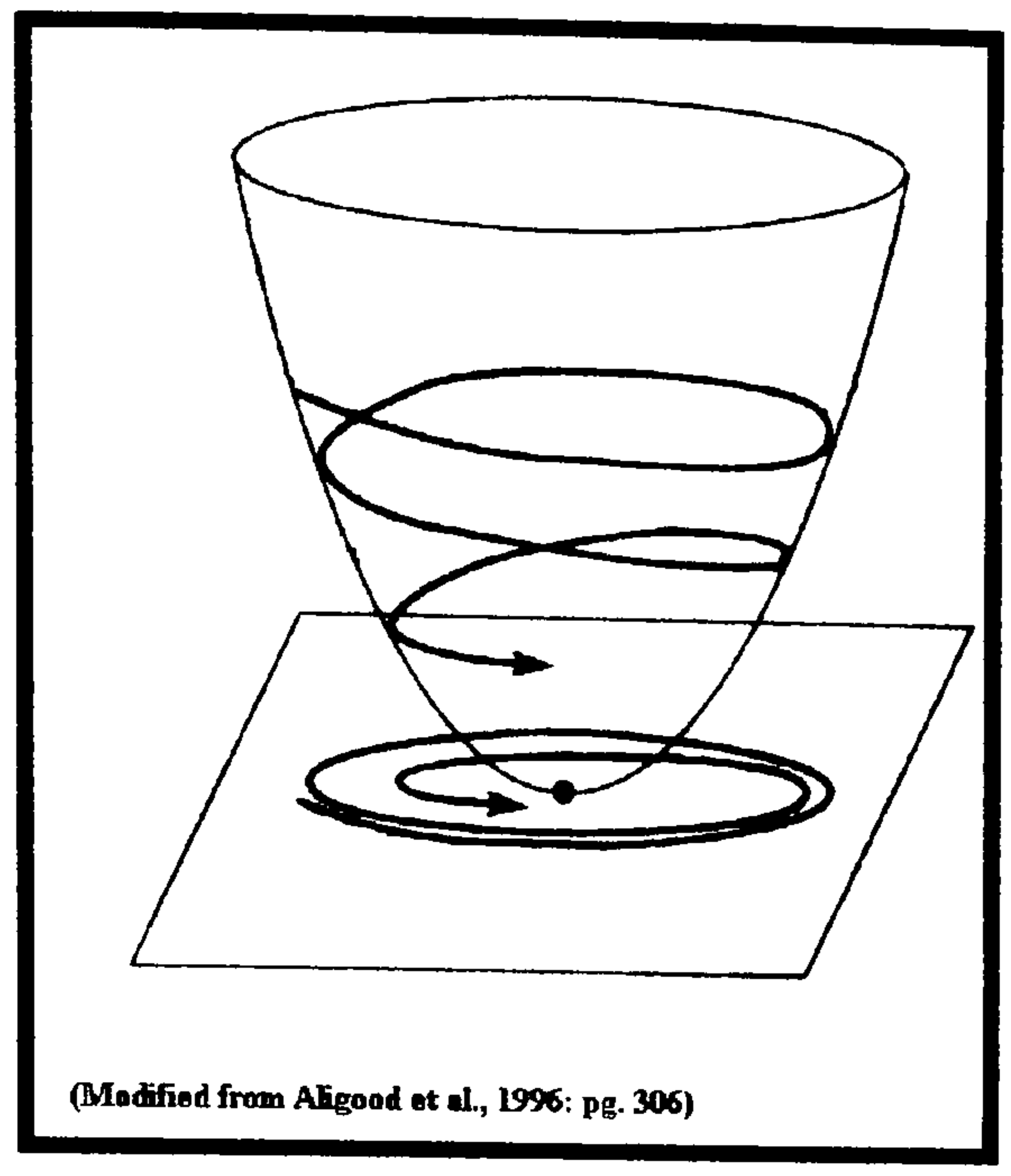


FIGURE 4.10 – This diagram is a representation of a point attractor, and it displays both the three-dimensional trajectory and the two-dimensional trajectory that could lead to the point of attraction. (Modified from Aligood et al., 1996)

be represented as a point in *state space*. With a little bit of experience with a system that has a point attractor for its characteristic state we can predict how long it will take the system to move from a given initial condition to the neighbourhood of its attractor. Knowing the attractor of a system allows us to know where in state space to look and how much time would be reasonable to expect the system to enter the region of the attractor. This does not tell us the specifics of the trajectory of a given system but it does make it easier than having to search the entire state space to find the system.

The concept of an attractor can be used to discuss the behaviour of living organisms. For example, the foraging behaviour of ants can be described as an attractor (see Figure 4.11). The initial condition of the ant colony represents the beginning of a new foraging cycle, such as after a rainstorm (or any other event that has cleared all traces of the previous foraging cycle). In the initial condition the ants leave the colony in random directions and wander through the environment searching for food. After a certain amount of time food is located and the foraging of the ants self-organises into the characteristic pattern that is shown in Figure 4.11. This pattern can be referred to as an attractor because each time the ant colony is returned to the initial condition it will self-organise fairly rapidly into a very similar and easily recognised pattern. The exact details of the pattern will differ from one foraging cycle to the next (even if the food sources are exactly the same in each cycle), but the patterns will be very similar. This variation in attractors will be discussed as part of the topic of *sensitive dependence*.

Ant behaviour is a self-organising entity because it is based on the inherent capacities of the individual ant and not a separate organising entity. Each ant leaves a

trail of formic acid when it is foraging. When the ant finds a food source it stops its random search behaviour and begins to transport food back to the colony. Transporting food back to the colony is efficient because the ant simply follows its trail of formic acid, and by doing so reinforces the trail with more formic acid. A randomly foraging ant that crosses this trail may choose to follow it to get food, which will further increase the strength of the formic acid signal of the trail. Strengthening the signal increases the probability that an ant crossing the trail will choose to follow it. Back at the colony food that is brought in is evaluated by the other ants, and the higher the quality of the food the higher the probability that some
ants will change tasks or food sources for the new one. On the other hand, no matter how high the quality of food, some ants will not change to the high quality food source. These few simple rules are all that is necessary to produce the self-organising complexity that is displayed by the colony of ants.

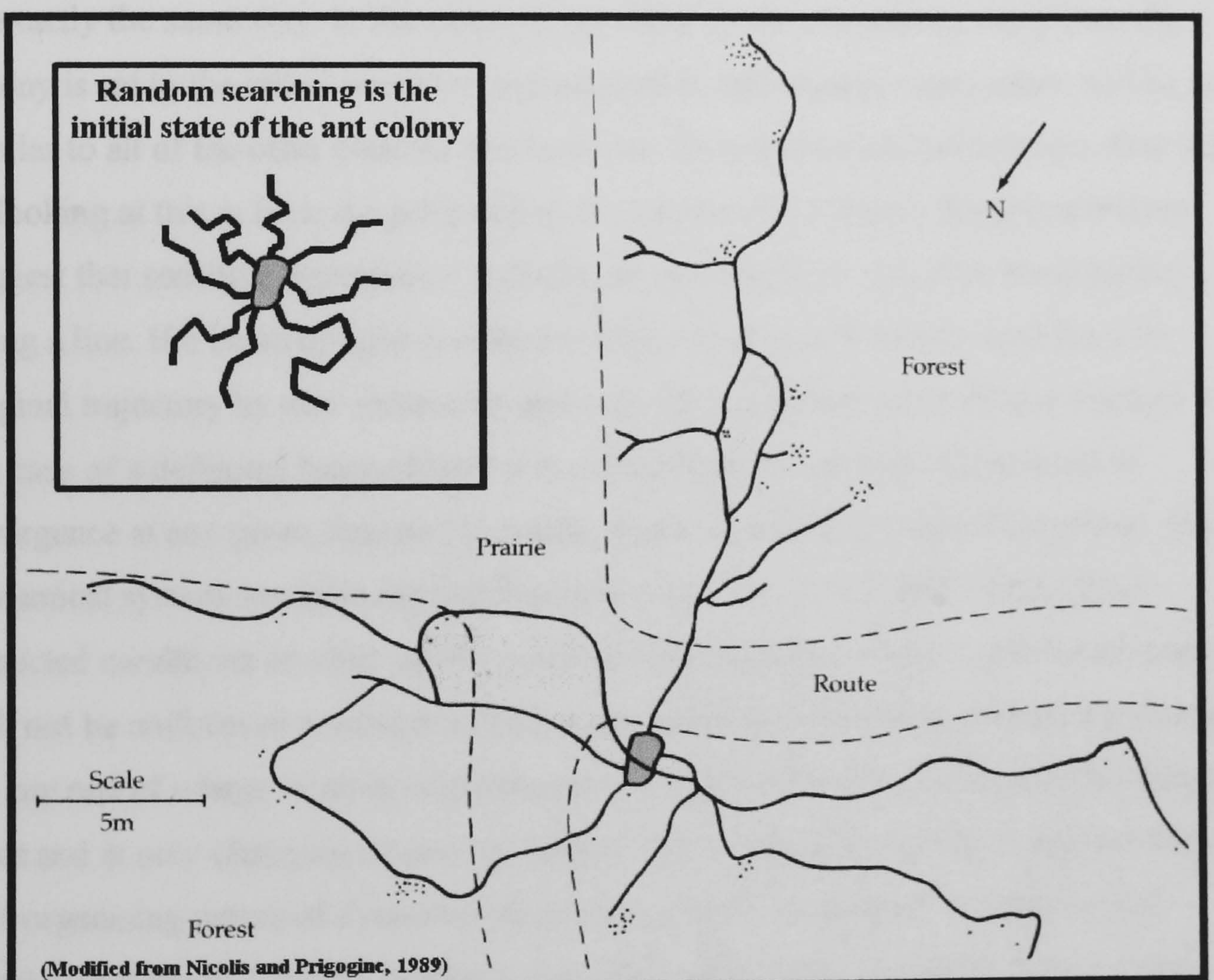


FIGURE 4.11 – This drawing represents the process of self-organisation into a recognisable attractor of foraging by an ant colony. In the inset the ants begin by randomly foraging for food, but their behaviour transforms to structured food collecting in a relatively short time. (Modified from Nicolis and Prigogine, 1989)

4.2.07 Sensitive Dependence

Many dynamical systems display extreme sensitivity to minute variations. Sensitivity to minute variations is referred to as "sensitive dependence", and it is primarily a function of the positive feedback processes that operate to give dynamical systems their characteristic transformational behaviour. Positive feedback loops involve aspects of the system in processes that produce multiple iterations (or repetitions) of interaction. Each iteration amplifies the impact of the elements involved, and differences in elements are also amplified. As the system progresses through many repetitions of the feedback loop very small differences are magnified to produce very large changes in the behaviour of the system. Systems dominated by positive feedback will diverge dramatically from anticipated behaviour if the system is observed over relatively long periods of time or if the positive feedback is very strong.

One of the interesting things about dynamical systems is that they never repeat in exactly the same way. In the example provided by the ant colony, every time the colony is set to the initial condition and allowed to self-organise the pattern will be very similar to all of the other patterns produced but the specifics will be different. One way of looking at this is from the perspective of *sensitive dependence*. Some researchers suggest that sensitive dependence is displayed in systems as simple as the trajectory along a line. If a beam of light is deflected only one degree it will diverge from its original trajectory by ever increasing amounts. This is a point of confusion because in the case of a deflected beam of light it is quite simple to calculate the amount of divergence at any given time and to predict (quite accurately) future divergences. In a dynamical system sensitive dependence means that the system will diverge from expected conditions or other nearby systems that differ only slightly, but the divergence will not be uniform or predictable. This is due to the fact that complex systems change on any one of a large number of parameters. A deflected beam of light is only changing once and is only changing on one parameter. One cause of this is due to the fact that the self-organising nature of dynamical systems is greatly influenced by positive and negative feedback. Positive feedback amplifies small differences until they are very large, but it can also move a system into a new regime where negative feedback can stabilise it. A nearby system (or the same system restarted in nearly the identical situation) will enter slightly different positive feedback regimes that miss or override the negative regime of the original system or they will enter a negative feedback regime sooner.

> "An immediate consequence of sensitive dependence in any system is the impossibility of making perfect predictions, or even mediocre predictions sufficiently far into the future." (Lorenz, 1993: 12)

One of the aspects of dynamical systems that constrains their sensitivity to initial conditions is the number of degrees of freedom of the elements of a system. The greater the degrees of freedom the elements have the more likely they are to enter rapidly diverging areas of state space. For example, weather forecasting is limited due to the sensitive dependence of fluid dynamics (Lorenz, 1993). The attractors that distinguish our daily weather are part of a vast fluid system that envelops our planet. These attractors are extremely sensitive to conditions, and this is why accurate weather forecasting beyond a five-day horizon is nearly impossible. The precision of the data required for a reasonably accurate two day forecast is twice that which is required for a one-day forecast. Each day you add to the forecast doubles the precision required so that a five day forecast requires data that is 16 times more precise than a one day forecast. Only one set of instruments is use to collect the data for all five of the forecasts. This means that the five-day forecast is 16 times less likely to be realised than the one-day forecast.

It may seem that sensitivity to initial conditions and rapid divergence are just confusing and make dealing with dynamical systems complicated, but they are actually useful aspects of dynamical systems. For example, when nearby complex systems do not diverge rapidly it can only be due to coupling between the two systems. As the coupling between two systems increases then the divergence between the two systems will tend to be either less pronounced or slower. For example, if the archaeological data demonstrates that two near by groups maintain a high level of similarity then DST can be used to state that these two groups are participating in a common flow of information. Also, aspects of the similarities of the two groups will provide clues as to the nature of the shared information. As DST becomes more sophisticated techniques for estimating or calculating the amount of coupling between nearby systems should improve greatly.

4.2.08 Determinism Or Non-Determinism

A dynamical system is not constrained to display deterministic behaviour, but the underlying processes or mechanisms of the system may be fundamentally deterministic. In the traditional concept of a deterministic system a qualitative change in the behaviour of the system (the system state) is caused by a qualitative change in the mechanisms of the system. This is not the case with dynamical systems. The system may progress through any number of transitions to qualitatively new and different system states without any change to the underlying mechanisms of the system. In other words, a dynamical system displays a consistent underlying process or mechanism (which tends to be relatively simple), but the system displays complex behaviour and transitions to a number of system states. This provides a basis for understanding a seeming contradiction in many natural phenomena. It is often noted that natural systems simultaneously display aspects of continuity and discontinuity. In dynamical systems lower level processes (relatively simple dynamics) produce a number of higher-level processes (or behaviours) that are relatively complex and display discontinuous aspects. The example of the Benard Cell is just such a case. The molecules of the fluid take on and give off energy in a deterministic manner, and the formation of the Benard Cell is dependent upon this deterministic process of energy transfer. On the other hand, the formation of Benard Cells in the fluid is completely non-deterministic.

Quite often deterministic processes produce non-deterministic behaviours within a complex system because the quantities needed for prediction are too small for accurate measurement (Lorenz, 1993). These quantities may represent an infinite regression. In other words the more sensitive our measuring devices become the smaller the uncertainty becomes, but it will never reach an uncertainty of zero. This condition means that these complex systems will forever be non-deterministic. On the other hand there is the possibility that at some level the measurements will detect some quantum barrier where they fall into a non-reducible value. At that point the systems would become deterministic, at least theoretically. At this point in time we can only wait to see what the future will bring. For now dynamical systems are for all intents and purposes non-deterministic.

4.2.09 Summary Of Dynamical Systems Theory

Dynamical systems theory presents an explanation of complexity that is based on the concept of an *open system* that is of the *many-bodied* type, which has *emergent* properties that *self-organise* into characteristic *attractors*. As open systems dynamical systems are formed and maintained by a flow through the system, and they display internal mechanisms that accumulate a portion of the flow. Accumulation of a portion of the flow plays a major role in moving the system towards a critical level where the system will experience a transition to a qualitatively distinct state. These states can be characterised as attractors, and the more degrees of freedom (or the larger the number of parameters) of the system the greater the number of attractors the system can potentially display. In fact very complex systems (such as cultures) can display a hierarchy of attractors where groups of attractors self-organise into an attractor of attractors. For example, humans display complexity at several levels – biologically, individually, and culturally. A specific form of culture can be thought of as a cultural attractor that is constituted by a number of individuals. Each individual represents an attractor state within the cultural attractor, and each individual can be described as a number of biological organs. Each organ can be described as a physiological attractor, and there are many more levels of organisation below that. All of these levels can be described as attractors within attractors.

Natural systems typically have a very large number of degrees of freedom, which can be expressed as a large number of parameters. For example, the number of parameters of a developing organism is virtually (if not absolutely) infinite. Each parameter is capable of autonomous change and producing changes to the system. Many of the parameters will function at different levels or on different scales, and any number of parameters may become involved in positive feedback loops that result in dramatic amplifications to small changes in the system. This aspect of dynamical systems is typically referred to as *input sensitivity* or *sensitive dependence*, and it is discussed as a prominent feature of this type of system (Kauffman, 1993).

This discussion of natural phenomena as natural dynamical systems is not meant to imply that natural phenomena are in reality systems. DST is a conceptual perspective for gaining knowledge about natural phenomena, but nature is not constrained by the concepts of DST or the non-linear mathematics that are employed to construct models of DST concepts. In other words, natural phenomena simply exist; DST concepts approximate the behaviour of natural phenomena, and non-linear mathematics approximate DST concepts. The fact that there exist a large number of phenomena that display behaviour that can be characterised by DST is what makes it such a powerful tool for gaining new perspectives and knowledge about natural phenomena.

Natural systems tend to consist of a large number of nearly identical elements. For example, most plants contain millions of cells. During the growing season of a plant it will take in mater and energy, transform some of the matter and energy into more cells (which it adds to its structure), and then give off energy and matter to the environment. Many plants will continue to grow and differentiate as long as conditions for maintaining a flow of energy and matter through its system are favourable. A plant can be described as a system of cells and processes that is maintained by a flow of energy and matter, and if you interrupt the flow of matter or energy the system will become unstable and collapse. As long as a flow of energy and matter is maintained through the plant it will capture a portion of the flow by constructing more cells and adding them to its structure. The process of adding cells represents a quantitative change to the structure (where the plant just gets bigger), but it can also represent a qualitative change to the structure (where the plant adds new types of structures that it didn't display before).

Any element within a natural dynamical system may potentially interact with any other element. For this reason dynamical systems are not inherently hierarchical. The perceived hierarchy that many authors discuss is an artefact of the author's perspective. The analogy of a network or matrix is more appropriate for general discussions of the arrangement of natural dynamical systems than is the analogy of a hierarchy. This is often seen in the fact that natural systems are embedded in a network of emergent properties, which is ultimately a cosmic framework. In other words, all natural systems can be described as being coupled to each other in some way, no matter how loosely or how weakly.

DST provides an explanation of complex systems that display discontinuous change, which is produced by continuous underlying processes or mechanisms. DST provides an appropriate basis for explaining cultural phenomena for two reasons. First, cultures fit the description of a many-bodied system. In other words, culture can be characterised as a complex system that is comprised of a large number of relatively similar elements (people). Second, the system attains complexity through the flow of information, which is based on the universal mechanism of learning. How ILT and DST can be combined to produce a general theory that explains cultural phenomena is the next topic of discussion.

4.3 COMPLEX-SYSTEMS THEORY OF CULTURE

A theory-based methodolgy represents an explanation of a phenomenon in terms of the underlying mechanisms that produce the phenomenon (see Chapter 2). This chapter contains a summary of two theories. The first theory that was presented is

ILT (Implicit Learning Theory), which I take to be an explanation of a fundamental universal aspect of human behaviour. From this perspective virtually all of the observable human behaviour is a direct product of learning. The second theory that was presented is DST (Dynamical Systems Theory), which I take to be the only extant scientific explanation of complex systems. DST presents a perspective for understanding the organisation and structure of complex systems, which can include cultural phenomena. These two theories constitute the underlying mechanisms that I believe are sufficient as an explanation of cultural phenomena. ILT explains human knowledge and behaviour from the perspective of a single learning mechanism. DST explains culture (as a complex system) from the perspective of information flow that is inherent in the human condition (as explained by ILT). The next section will consist of a discussion of how ILT and DST can be combined to explain cultural phenomena.

Implicit Learning Theory explains how an individual collects information, assigns meaning to it, integrates it into their knowledge system, and then employs that knowledge to interact with their environment. Dynamical Systems Theory provides an explanation of the complexity that is displayed at both the level of the individual and the level of culture. By combining ILT and DST it is possible to synthesise a general theory of culture that can be used as a general explanation of individual and cultural phenomena, it can be used as a framework for developing fine grained explanations of specific aspects of culture (based on special theories), and it can be used to suggest which data need to be collected in cultural research.

4.3.01 An Information Perspective Of Culture

Ian Hodder (1985) suggested that we should seek to know human universals that produce social organisation. Lewis Binford (1989) suggested that theories need to be constructed from concepts that were not a part of the researchers project, and he states that archaeologists must accept the responsibility for synthesising their own theory because no other scientists are studying archaeological phenomena. The search for cultural universals has been singularly unproductive, and the field of archaeology has never been unified under a general theory. Today's archaeology is still characterised by a large number of competing paradigms (Hodder, 2001). This is evident in the large number of books on archaeological theory, each with its own particular view (see Teltser, 1995; Preucel and Hodder, 1996).

A review of what we know about artefacts can be summarised like this:

1) Artefacts are the direct product of behaviour.
2) Behaviour is specified by knowledge.
3) Knowledge is produced by experience within an environment (information).

This is a top-down analysis, and this is where it usually ends because a superficial reading of this regression suggests that artefacts are the product of experience within an environment, which doesn't explain anything in a non-trivial and general sense because "experience within an environment" is just as particularistic as are the artefacts to be explained. In other words, experience, knowledge, and behaviour all fail as adequate underlying mechanisms for a theory that purports to explain culture. This can be demonstrated by the fact that all of these represent categories containing large numbers of specific conditions within a process, but the mechanisms that are proposed to explain a phenomenon must be limited to a small number (preferably one or two). Binford expresses the archaeologist's dilemma as follows:

> "Traditional archaeology could not address itself to the testing of theory, since relevant information on assumed seats of causation was not preserved. In addition, the results of the operation of causal forces could only be described and systematised but could not be investigated, since there were thought to be no regular relationships between similar material things and the meanings – the cultural contexts – in terms of which they were integrated in the minds of past humans. The paradox of adopting a strict empiricist's view of science while at the same time adopting an idealist's theory of causation, where the "black box" – the minds of the ancients – was not available for investigation, placed archaeology in a strange position indeed." (Binford, 1989: 14)

This highlights the fact that archaeological theory is not adequate for engaging the issues that are of interest to archaeologists.

A bottom-up approach suggests that the process of learning explains how experience within an environment produces knowledge. This is an explanation of knowledge, behaviour, and the material components produced by them in terms of a universal mechanism that can be characterised as "learning". This approach had always been problematical because traditional *learning theory* had focused on hypothetical mechanisms that are inadequate for explaining cultural behaviour. Experimental psychologists were investigating learning through aspects of conditioning, but anthropologists found the idea of culture based on conditioned responses to be less than convincing or compelling. Unfortunately the mechanisms of teaching, trial-and-error, and consciously directed insight, which were proposed by many anthropologists, proved to be no more satisfactory than conditioning. A recent development within experimental psychology has produced a viable alternative called Implicit Learning.

Implicit learning is a mechanism that is loosely analogous to the mechanism of "heredity" in Darwin's theory. From an information perspective heredity can be stated as the process of transmitting information that is used to specify the characteristics of the next generation of an organism. Attempts to employ this analogy directly to cultural entities have failed to produce non-trivial results (Teltser, 1995). The reason for this is that genetic information and cultural information are not analogous (see Figure 4.12). Genetic information is discrete, complete, and transmitted directly to exclusive individuals that become members of the next generation. Cultural information is continuously transmitted inclusively to all individuals within an environment. The formulation of cultural "characters" (knowledge) is directed by the process of learning at the level of the autonomous individual. Each individual formulates their own knowledge based on parameters such as their unique capabilities, the information they experience, their interactions with other members of social organisations, the environment, and the timing and amounts of the different types of information that they are exposed to. In other words, a new cell starts with a maximised amount of information, but a new cultural entity starts with a minimum of information and constructs *information acquisition systems* tailored to the information flow provided by experience. These fundamental differences ensure that the concept of *meme* as a

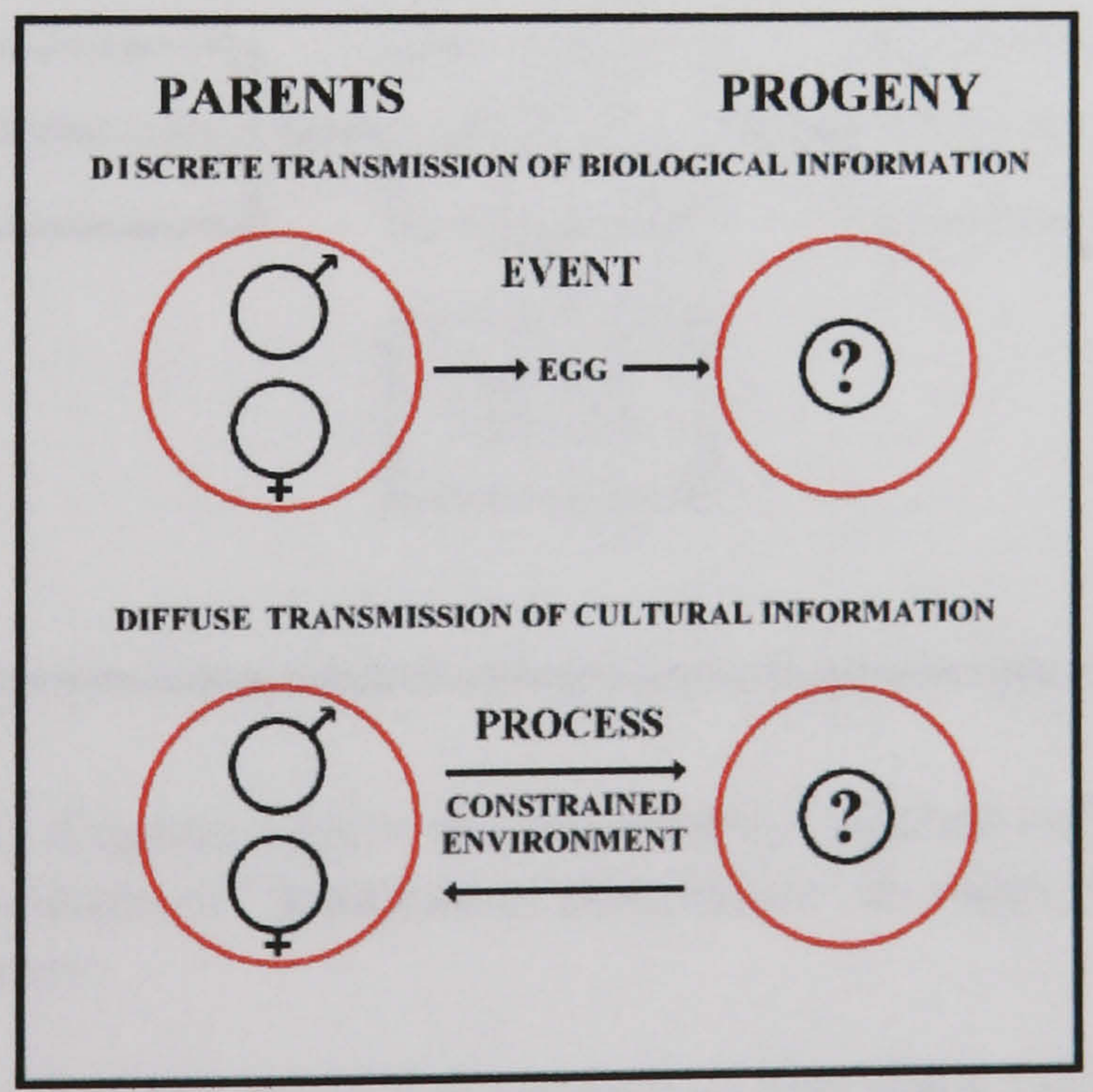


FIGURE 4.12 – This is an abstract representation that displays some of the distinctions between genetic information transmission and cultural information transmission.

cultural analogue to the concept of gene will always produce trivial results in understanding cultural systems. Another aspect of cultural information systems that make them qualitatively more complex than genetic systems is that information can flow from the parent to their progeny and from the progeny to their parents. The complexities of cultural information transmission require a powerful organising mechanism, which I suggest can be found in DST.

The relationship between information and knowledge can be expressed in terms of the mechanism of Implicit Learning (see Figure 4.13). Implicit learning theory states that humans detect information in the form of sensory stimuli (Reber, 1993). Learning takes the form of detecting covariation of events within the information, and the assigning of meaning to the relationships detected. The product of learning is knowledge, and knowledge is used to specify behaviour and to act as *higher order learning systems*. In other words, learning alters our behaviour by altering our knowledge, and our altered knowledge changes how we interact with the environment and how we perceive it. Figure 4.14 indicates this feedback relationship between acquired knowledge and subsequent information assessment, which has several consequences. First, the learning process is not deterministic. Second, no two individuals will develop exactly the same knowledge. Three, learning is a complex dynamical process that is best understood from a DST perspective.

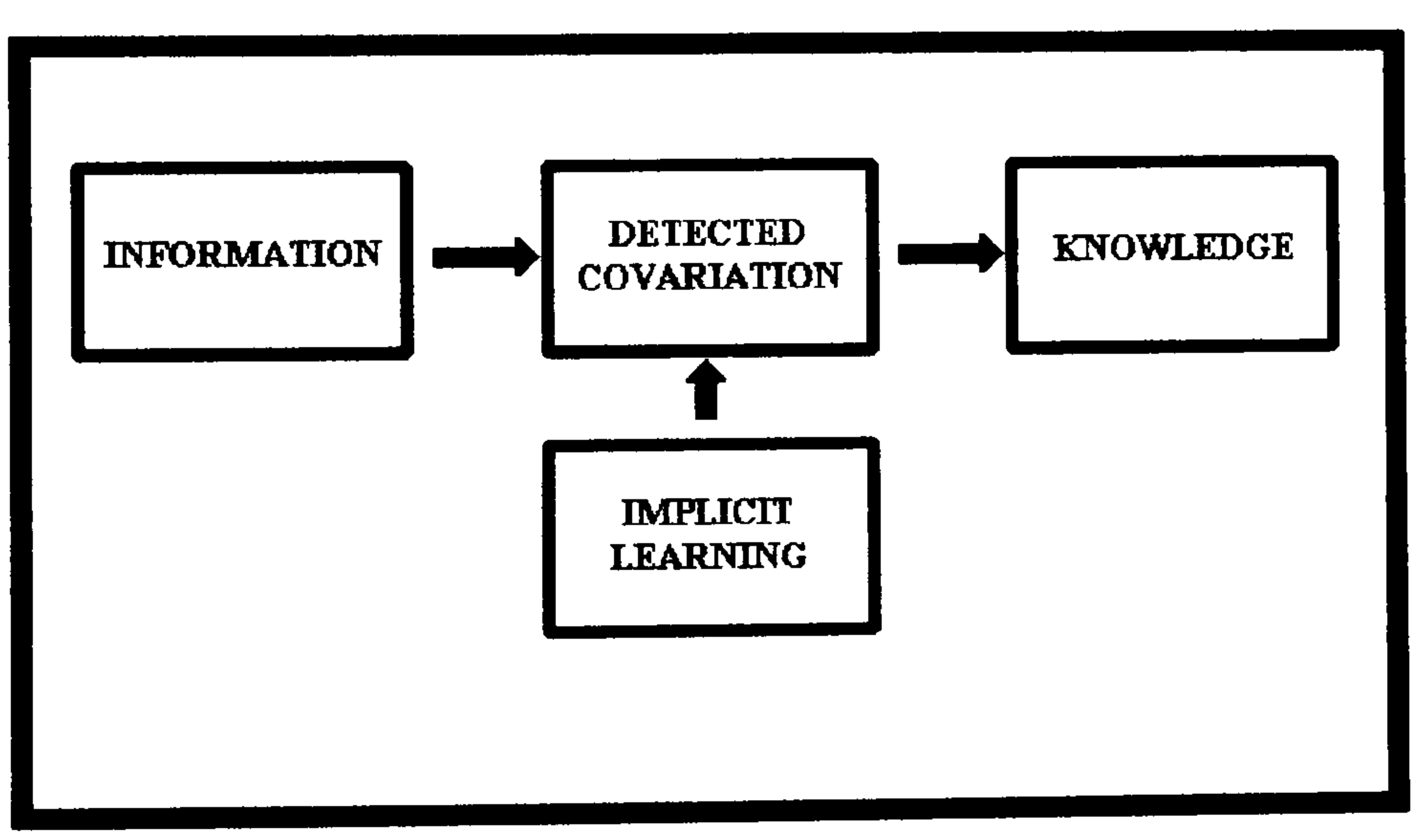


FIGURE 4.13 – This diagram depicts the relationship between information and knowledge in terms of "detection of covariation" as explained by Implicit Learning Theory.

Learning is a complex process of interaction between an individual and their environment. This means that any group of individuals living in a uniform information environment will tend to have very similar knowledge, but some of the individuals may develop along trajectories that produce knowledge that diverges significantly from the typical knowledge of the group. Information displayed in the behaviour (and material products of behaviour) can be analysed to distinguish between knowledge that is constrained by social organisation and knowledge that is freely variable.

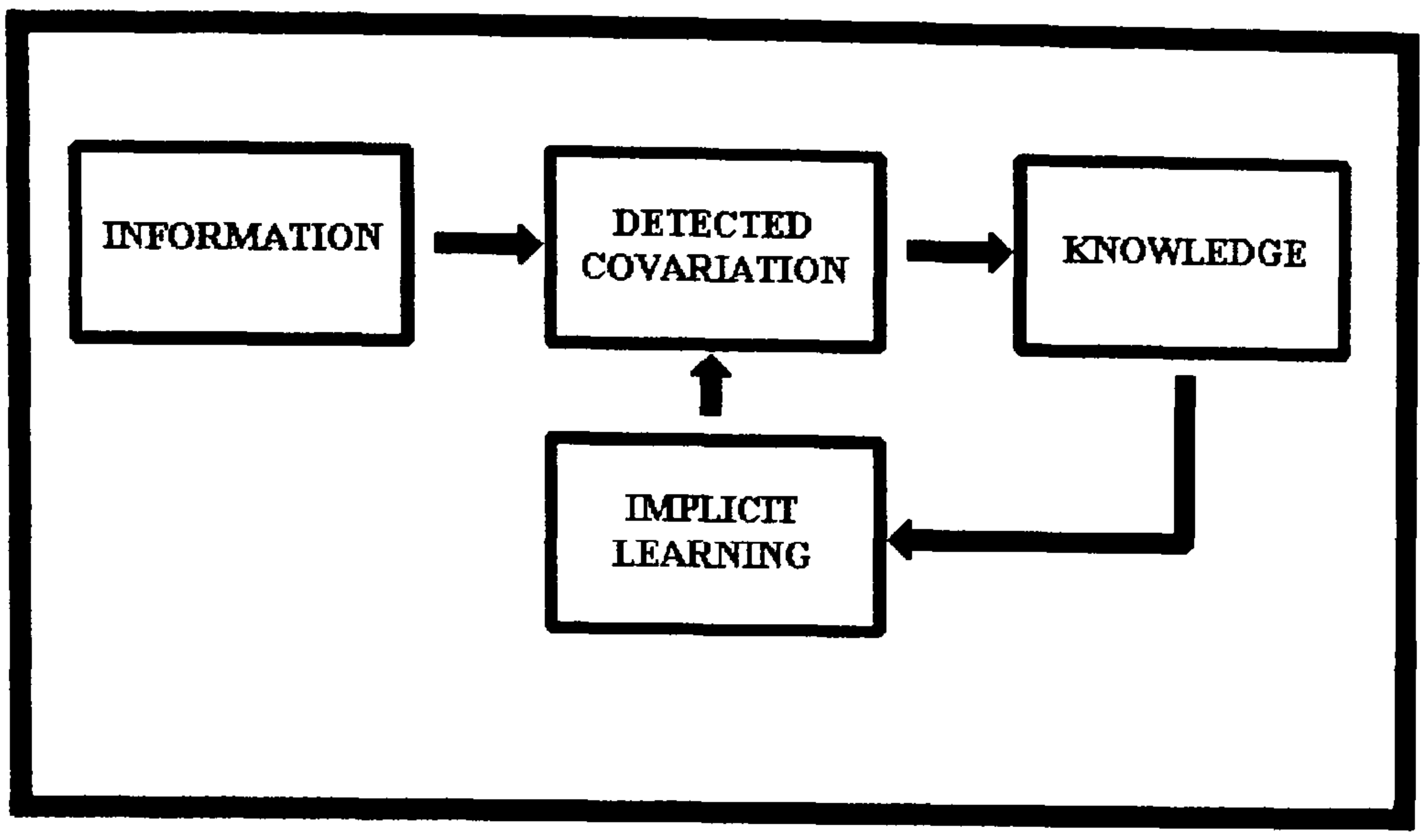


FIGURE 4.14 – This diagram represents the feedback relationship between knowledge and the continuing assessment of information and the acquisition of new knowledge.

The perspective presented here is that the individual is the fundamental unit of cultural phenomena. Individuals have knowledge and they act on and within a cultural environment, but an individual is not a culture. A culture is a complex system that is best described as a many-bodied system. This means that cultural phenomena are the product of many individuals interacting in a coherent collective. The first step in understanding what culture is and how it functions is to understand how the individual acquires knowledge and how that knowledge is used, which means explaining what makes individual humans complex.

4.3.02 The Individual

Nature can be described as one vast integrated system. From this perspective all restricted systems, such as biology, culture, the individual…, are arbitrary and synthetic categories constructed by researchers (Dunnell, 1995). When a researcher defines a system to be investigated it is very important to maintain an awareness of the bounds of the conceptual framework that is imposed. Similarly "complexity" can be discussed at many levels within a system, and the aspect of the system that is evaluated for complexity is a conceptual construct of the researcher. For example, E. O. Wilson (1975 and 1978) demonstrated that a colony of ants (as a coherent collective) could display many complex behaviours. Wilson also demonstrated that an individual ant's behaviour is based directly on *instincts*, which means that the ant's behaviour is a genetically specified reaction to environmental cues, and the ant's instinctive behaviour is highly predictable. He used these two facts to state that the complex behaviour of cultures is directly based on instinctive behaviours in humans. Wilson failed to maintain adequate control of the boundaries of the systems he was discussing, which resulted in his confusing the complex behaviour of an ant colony with the complex behaviour of human cultures. He failed to recognise the fact that an individual ant displays simple (nearly deterministic) behaviour, but an individual human displays complex (non-deterministic) behaviour. Complexity of behaviour for an individual human is distinct from the complexity of a coherent collective of humans. To understand the collective we must understand something about the nature of the individuals that comprise the collective.

Humans begin life with a very limited repertoire of behaviours and a vast potential for acquiring knowledge (and behaviours). The human developmental cycle is long and slow, realising a large repertoire of complex behaviours. This is an iterative process where acquired knowledge and behaviours places the individual in contact with new information and allows them to perceive information that was previously transparent to their abilities or comprehension. In this way the developing human experiences a period of rapid development followed by a subsequent slowing. The latter is due largely to settling into a pattern of repetition that we refer to as the *daily routine* where the information that is perceived each day is much the same as the day before. The combination of ILT (Implicit Learning Theory) and DST (Dynamical Systems Theory) can be used to explain this developmental process.

ILT describes humans as autonomous agents who are immersed in a richly intricate network of information that is vast in proportions. Humans have evolved to detect this information and assign meanings to the relationships of co-occurrence provided by this network of sensory stimuli (Reber, 1993). According to ILT the mechanism of learning is almost completely outside of conscious control; in fact even when an individual consciously decides to learn some specific knowledge the learning takes place at an implicit level. The process of learning and the content of what is learned are not subject to conscious control (Reber, 1993). In other words, knowledge acquisition appears to be an autonomous process that is a fundamental and universal aspect of each individual.

Once knowledge is constructed it is used to direct the behaviour of the individual, and this transmits information back into the environment (Reber, 1993). This represents an information flow (from the environment to the individual and then back to the environment) that is characteristic of the dissipative systems described and explained by DST. The concepts of ILT and DST provide a framework for understanding the self-organising nature of the individual within a cultural context.

Human knowledge is acquired through learning processes, and is involved in a lengthy developmental cycle. Researchers have demonstrated that the learning process can be detected as early as three months before birth (Maurer and Maurer, 1988). At birth a neonate has physiological and perceptual abilities that focus its attention on large-scale aspects of the world around it. For example, neonate visual acuity is roughly 30 times less than that of an adult (Bremner, 1994), which means that the smallest object a neonate can perceive must be at least 30 times larger than the smallest object an adult can perceive. Also, a neonate's contrast sensitivity is roughly 30 times less than that of an adult (Bremner, 1994). Not only do neonates have innate mechanisms that restrict the type and volume of information they are subjected to, they also take an active role in regulating exposure to information. Attentional mechanisms direct the perception of infants to specific types of information, but also infants actively regulate information flow, for example, by going to sleep (which reduces sensory input) or by crying (which can block sensory input) (Maurer, 1993; Jackson and Jackson, 1978). This means that even in the earliest stages of development humans display both the positive and negative feedback regimes that are inherent to all complex systems.

A good foundation for the developmental cycle is provided by Cooper (1995) in his discussion of the functioning of our neural networks. Research in neural science has demonstrated that there are three types of neural networks. Some are experience *independent*, some are experience *expectant*, and some are experience *dependent* (Cooper, 1995). The structure and function of experience independent neural networks is largely specified genetically, and most, if not all, of the functioning of these networks is due to their innate specification and maturational processes alone. In other words, experience has little if any affect on the functioning of these neural networks. Experience expectant networks have a gross structure that is specified genetically, but these networks require developmental experience to fill in the fine points of their functioning. In contrast, experience dependent networks have very little, if any, innate function or structure, and they depend almost exclusively on experience for their function and structure. Human neural networks are largely *experience dependent networks* that attain a functional structure through the guidance of a relatively small number of experience expectant and experience independent neural networks.

The developmental cycle of the human knowledge system is an iterative process, and Figure 4.15 is a graphical representation of this process. In Figure 4.15 the green arrows indicate the paths along which information is acquired through learning, and the pink arrows indicate the paths along which the information content of our knowledge is displayed. This diagram indicates that an individual's *Knowledge System* produces their *Behaviour*, and their behaviour modifies the structure of the environment. Through normal interaction with other organisms and the physical environment we accumulate information through the learning process, which alters their *Knowledge System*. Our altered knowledge system results in changes in our behaviour, which in turn alters the structure of our environment. Each cycle of learning results in a new set of knowledge, behaviour, and environmental structures.

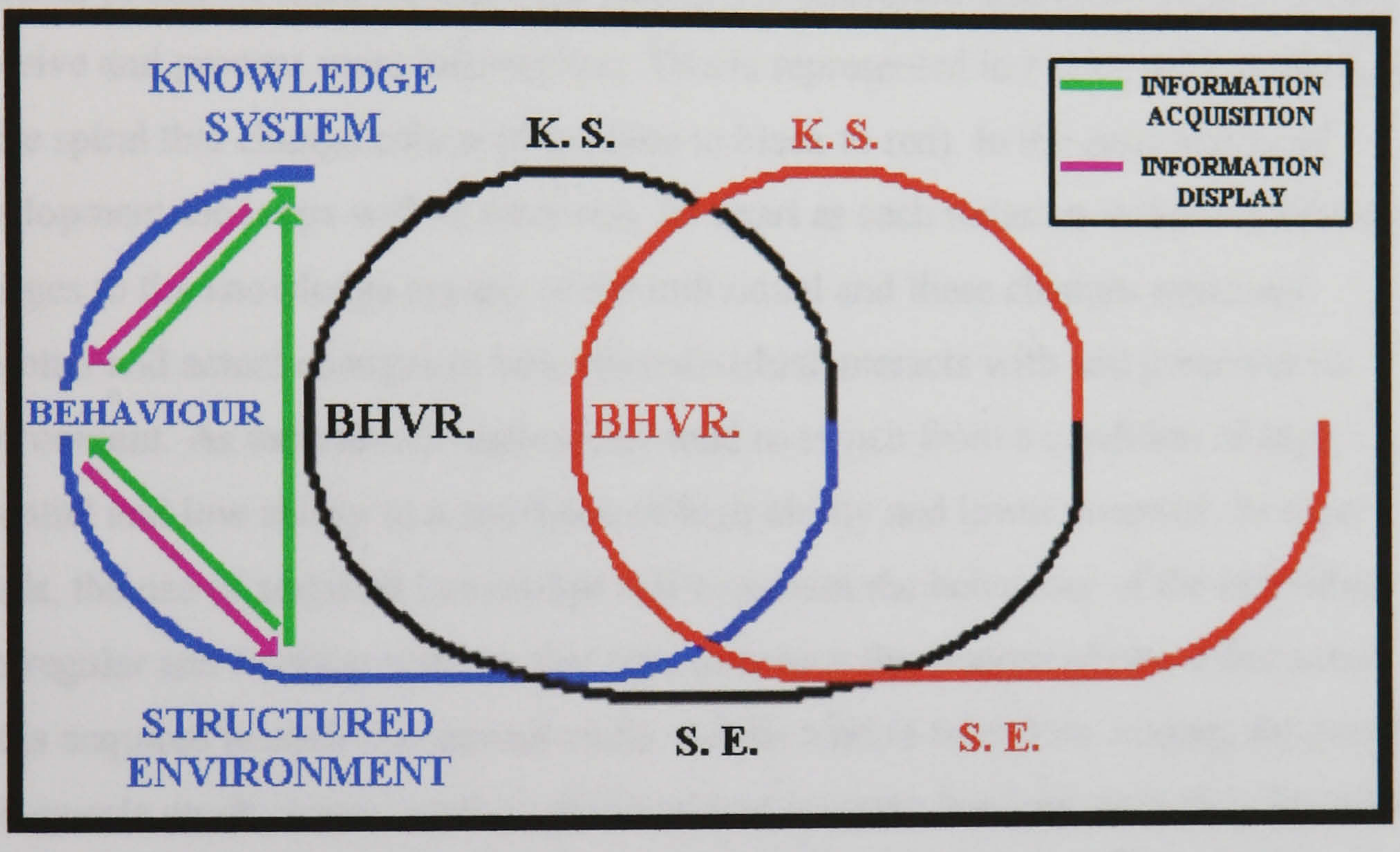


FIGURE 4.15 – This is an abstract representation of the self-organising nature of information, knowledge, behaviour, and the structured environment.

A neonate enters the cultural system with a vast potential for learning that is guided by innate mechanisms. The Knowledge Systems of the neonate are constrained to mostly passive acquisition of information and knowledge due to the very low maturation level of humans at birth. Neonates have basically two tools for manipulating their cultural environment, looking cute/helpless and crying (Jackson and Jackson, 1978). Passive acquisition of information is indicated by the green arrow that points from *Cultural Environment* to *Knowledge System* (Figure 4.12). Humans perceive a constant flow of information and constantly assess it for appropriate meaning. For roughly the first two years of life this is the dominant form of knowledge acquisition for humans.

Traditionally this period has been viewed as almost exclusively dominated by the mechanisms of maturation, but considerable research in the last two decades has demonstrated that much of what had been attributed to maturation is actually developmental processes (which are based on learning).

Part of the behaviour of the individual that is affected by learning is the learning process itself. Acquired knowledge becomes an integral part of perceiving, organising, and assigning meaning to subsequent information (Reber, 1993). The individual is actively engaged in accumulating information and knowledge, and the subsequent use of acquired knowledge represents opportunities for negative and positive feedback relationships to self-organise the individual's knowledge system.

In the early development of the individual the information flow contains large amounts of unprocessed information, and as it is converted into knowledge it is used to perceive and process more information. This is represented in Figure 4.12 as the loops of the spiral that change colour (from blue to black to red). In the early stages of development the loops will be relatively far apart as each iteration makes significant changes to the knowledge system of the individual and these changes represent potential and actual changes in how the individual interacts with and perceives its environment. As individuals mature they tend to switch from a condition of high potential and low ability to a condition of high ability and lower potential. In other words, the use of acquired knowledge self-organises the behaviour of the individual into regular and familiar patterns that tend to reduce the amount of new information that is acquired in each subsequent cycle. Adults tend to learn less, making the loops of their spirals much closer together, than children because they are using their knowledge to perform chosen or imposed tasks, and because the knowledge network becomes more resistant to change as more knowledge is integrated into the matrix. In other words, learning a skill will typically produce dramatic changes in our behaviour, but practising a known skill constrains our behaviour to be relatively stable and consistent. This does not mean that adults have less ability to learn (Reber, 1993), but this does mean that adults tend to require a higher level of motivation to learn than a child would for an equivalent task.

Another reason that the learning process tends to slow down is that some early knowledge becomes a fundamental aspect of later knowledge organisation. Knowledge that is acquired early in the developmental process becomes fundamental to later knowledge and, therefore, becomes resistant to change (much as the foundation of a house is more difficult to change once a house is constructed on it). This could account for several effects documented in language acquisition. For example, newborns have demonstrated the ability to hear all of the sounds that can be found in any language, but as they gain experience with their own language they lose the ability to perceive sounds that are not part of their language. Also, people who are deprived of linguistic experience until they are adults or young adults (for instance infants that are profoundly deaf and blind) tend not to achieve the same level of linguistic competence as others. Another example is the difficulty with which adults acquire a second language. Reber (1993) demonstrates with the artificial grammar research that the ability to learn is still there, but higher levels of motivation are required to reorganise the existing linguistic knowledge to accommodate the new knowledge and behaviour.

By the time a human has attained a significant level of competence (around two years old) its mode of knowledge acquisition will become more balanced, and active interaction will account for a substantial amount of information acquisition. This is denoted by the green arrows (Figure 4.12) that point from the *Cultural environment* to *Behaviour* and then to *Knowledge system*. Prior to this point an infant is limited in its ability to interact with the world, and it is limited to a predominantly reactive mode of behaviour. By the age of two a young human's interactions with its cultural environment provides it with vast amounts of information that can become part of a positive feedback loop that sends an individual on any one of a number of divergent behavioural trajectories.

The complexity of the human individual is a result of the broad spectrum of behaviours and beliefs that any individual can form within the influence of a given environmental context. The typical individual will reorganise their knowledge system a number of times before they reach the relative stability of the adult phase of life. Each of these reorganisations can be characterised as a behavioural attractor. Each individual has many mental modules, any of which can become the focus of subsequent development, and each can send the individual off on a divergent trajectory. Unlike American evolutionary psychologists (such as J. H. Barkow, L. Cosmides, and J. Tooby) I perceive "mental modules" as self-organising attractors of knowledge that are a part of the developing mind. American evolutionary psychologists claim that "mental modules" are genetically specified and biologically evolved aspects of the brain. Only through the processes of self-organisation do individuals within a common culture typically converge on a consistent set of similar behaviours and beliefs.

4.3.03 Cultural Mechanisms

All humans are both quite similar and absolutely unique, even monozygotic (identical) twins have unique neural connections (Cooper, 1995). This represents a situation where relatively unique individuals within a given culture display very similar beliefs and behaviour. On the other hand, the small differences found in any given individual can be magnified to produce a relatively distinct individual that is noticeably, and some times profoundly, different from the typical (this is often referred to as *sensitive dependence*). The concepts of DST and ILT can help to explain this seeming dichotomy.

From a common sense perspective it seems obvious that similar individuals raised in similar conditions should produce similar behaviours and beliefs. For the most part this is the typical condition that has been observed by anthropologists in all cultures. Humans can be described as complex systems, and DST demonstrates that all complex systems will tend to diverge from each other unless they are coupled. It is the fact that humans interact in a social environment and participate in a common flow of information that produces the coupling that results in the typical similarity of individuals that is observed in all cultures.

Two complex systems can be similar because they have developed along similar paths from similar starting conditions. DST states that this will only happen when complex systems share coupling mechanisms and self-organise into a local attractor. On the other hand, DST demonstrates that dissimilar systems with dissimilar potentials and conditions can converge to display superficially similar behaviours. DST states that these two different conditions of similarity can be distinguished from each other by comparing their underlying mechanisms and structures. For example, a dolphin may look quite similar to a large fish, but the internal physiology of the dolphin displays numerous indications of a quite distinct past from that of a fish.

Another commonly held belief is that individuals that display large differences in behaviour must have proportionally large inherent differences or they must have experienced proportionally large differences in developmental conditions. DST demonstrates that this is not necessarily so. Two individuals that are nearly identical in potential and social experience can display dramatically different behaviour and beliefs. This is due to the fact that complex systems display sensitive dependence, and sometimes that sensitivity can produce largely divergent trajectories for some individuals. One way of seeing this is that in some individuals an aspect of their innate potential or social context can become caught up in a positive feedback regime that amplifies a relatively small difference until it appears to dominate the behaviour or beliefs of the individual. The fact that some elements of a highly organised system do diverge is not surprising because all complex systems have broad spectrums of behavioural potentials for any given inherent condition expressed in any specified context. In other words, complex systems have a vast potential for displaying distinct behaviour, and whenever a number of elements consistently display similar behaviour it is an indication that they are part of a self-organised local attractor. On the other hand, complex systems are not deterministic so we should expect some elements of the system to diverge from the typical behaviour that is displayed by the other elements of the system.

One way of looking at the knowledge of the individual is to make a distinction between the part of their knowledge that is constrained by the group and the part of their knowledge that is relatively unconstrained and varies freely. Almost all of the information that is available to any individual is constrained by the culture of the group. The interaction of the group with the environment sets the context within which all information is collected, but individual variation within this context can be quite broad because the individual assigns meaning to the information from an internal perspective. Typically the interaction of the individual with the cultural environment acts as a regulating influence (negative feedback) that reduces the affects of individual and developmental differences. A comprehensive discussion of the specific mechanisms involved in this process is beyond the scope of this project, but *approval* of correct behaviour (and thinking) and *disapproval* of incorrect behaviour (and thinking) are obvious and powerful examples.

Figure 4.15 is an idealised representation of how the system works using just the approval/disapproval mechanisms. Suppose that through passive perceptual processes the infant constructs the knowledge that all four legged animals are 'dogs'. When they display this knowledge in a context where it is correct (or more precisely it is perceived by others of the group to be correct) there will typically be either approval of the displayed information or very little response due to the obvious correctness of the display. These responses (or lack there of) provide positive feedback for the knowledge, and it becomes more substantial with each correct usage. On the other hand, displaying this knowledge in an incorrect context (referring to a *cat* as a *dog*) will typically evoke responses that indicate an error in the information transmitted by the young individual. In this way the knowledge system of a developing human is typically regulated to attain a relatively high degree of similarity to the other members of the cultural group. On the other hand, the complexity of cultural systems is such that the incorrect usage of 'dog' can produce laughter and attention that acts as a positive reinforcement for the incorrect behaviour. Typically this would be only a short-term event in the individuals life, but it could also be the beginning of a positive feedback loop that sends the individual on a relatively divergent trajectory.

Figure 4.15 can be used to discuss the trajectory of a culture as well as the development of an individual. The knowledge of the culture is the sum of the knowledge of all the individuals of the cultural collective. The knowledge of the culture can be characterised as two distinct types. One type of cultural knowledge is that which is constrained by social organisation within the cultural collective. This "shared group knowledge" is constrained by cultural mechanisms to be very similar for the entire group, but there may be many distinct "groups" within the knowledge structure of a culture. The degree of similarity of knowledge within and between groups is dependent on a large number of parameters. Fortunately cultural processes provide clues for distinguishing between groups at equivalent levels of organisation within a culture and collectives of groups at different levels of interaction. The behaviour of the group modifies the physical environment and in the process converts it into a cultural environment that displays the information contained in the knowledge of the group, and the patterns of knowledge displayed by the groups provide clues to the structure of the social organisation. The second type of cultural knowledge is the "personal individual knowledge" that is not a part of the socially shared knowledge of the group. The personal knowledge of the individual is not subject to the same social constraints as the shared knowledge of the group, therefore it can vary to a much greater degree.

Cultures, like individuals, can be in a phase of relative stability (not acquiring very much new information) or relative development (acquiring significant quantities of new information). All cultures typically accumulate more information as time passes, but the relative level of information accumulation can have dramatic consequences for the trajectory of the culture. At low levels of information accumulation a culture can remain relatively unchanged for thousands of years. At very high levels of information accumulation the culture can accumulate a vast quantity of new information in a single generation. At high levels of accumulation a culture can experience rapid transformations or structural/functional reorganisations in very short time frames.

DST is useful for explaining several aspects of these cultural phenomena. When a complex system is functioning close to a condition of natural equilibrium it tends to accumulate information at a relatively low rate and transformations will be relatively far apart. The farther the system moves from equilibrium the more rapid information accumulation becomes and the more frequent and profound the transformations are likely to be. At this point it is necessary to understand what constitutes an information equilibrium within a cultural context.

Ideas and knowledge are not directly observable, but reasonable reconstructions of knowledge and its social organisation can be inferred from the information contained in the material components of past cultures in much the same way that the existence of an unobserved planet can be established by its gravitational effects on known planets.

4.3.04 Cultural Information Equilibrium

Social organisations that are near to information equilibrium provide for a highly regulated information flow and a high degree of social constraint on knowledge for many aspects of an individual's life. Group activities are inherently constrained to an appropriate level of conformity. Tools and resources are shared among a number of individuals during the group task. This constrains the individuals to use the tools and resources in a very similar way or disputes and waste becomes increasingly excessive. Using the *Complex Systems Theory of Culture* the process illustrated in Figure 4.15 provides a model of how this works. Assuming an initial point where the group has developed a behaviour that provides something for the group, such as a brush hut. If everyone has a similar understanding of how to make a brush hut then they can all participate in the phases of selecting a suitable location, collecting the necessary materials and constructing the hut. This can be a very efficient operation if everyone has a very similar set of ideas about how to build a brush hut. On the other hand, the more differing views there are in the group about brush hut construction the more time is lost to discussions about which type to build, where to build it, what materials are required, and what the appropriate technique is. A young individual entering the group that has achieved a high level of similarity in their ideas about brush hut construction will learn those ideals first through observation and then through participation. Interaction within the group provides clues to the meaning of the information perceived by the young individual and reinforces correct behaviour (and ideas). It is very difficult for the individual to develop significantly different behaviours (and ideas) about group activities. In larger groups it is possible for a new *tradition* (such as an alternative for brush hut construction) to emerge through the division of the group into two or more subgroups. This discussion represents a simplistic example of how information, knowledge, behaviour, and their material products are integrated within the CSTC explanation of cultural process.

Dynamical Systems Theory demonstrates that all natural systems, such as cultures, tend to increase in complexity over time because they are maintained by a flow of information and they accumulate increasing amounts of the information that flows through the system. The flow of information is necessary for maintaining the cultural system because cultures have no internal physical structure (often referred to as a static structure as discussed in Chapter 4). In other words, if the information flow decreases to a level that is too low the system will lose its coherence, and the recognisable patterns of organisation will cease to exist.

Information flow not only maintains the configuration of cultural systems it provides the basis for internal mechanisms that transform the system into new configurations. All natural systems will accumulate a portion of the flow that maintains their configuration. In cultural systems this is due to the fact that the elements of the system are humans and humans learn and accumulate knowledge (Reber, 1993). As the system accumulates information its configuration becomes more complex and differentiated. This is due to positive feed back loops between the amount of information contained in the system and the ability of any given configuration to store and accumulate information. Recognising and analysing the significance of complexity in a natural system is a fundamental point of departure for this research, and I will begin to discuss this in the next section.

In Dynamical Systems Theory one measure of a system's complexity is the distance from a state of natural equilibrium that the system maintains. A natural equilibrium in a cultural system is a condition of relatively homogeneous information flow (uniform information flow between all individuals in the system), which also represents a minimum of information accumulation. This is represented by the diagram of information flow in Figure 4.16. This diagram illustrates an idealised abstraction of information flow that has probably never existed in human history. It is meant to illustrate what a condition of absolute information equilibrium would look like. DST demonstrates that systems that are relatively close to a state of equilibrium will tend to function very similarly to a system that is actually in the equilibrium state.

Figure 4.16 represents a group of six individuals and the arrows represent the direction and magnitude of information flow (the width of the arrows is uniformly equivalent indicating an equivalent amount of information). This diagram illustrates a condition where each individual shares information with every other individual in the group, and the information flow is symmetrical. In other words similar and equal amounts of information flows in both directions between each individual. In fact in a group such as this much of the information flows to all of the members of the group at the same time and is not limited to one-to-one interactions. This is the type of information flow that would be expected for the example of brush hut construction where all members of the group participate in the construction of a single type of hut. Information, knowledge, behaviour, and their material products are integrated into a self-organising, self-replicating, and self-reinforcing unity. This means that shared information constrains knowledge, behaviour, and their material products to level of relative similarity. From this perspective, random variations that are distinct from the

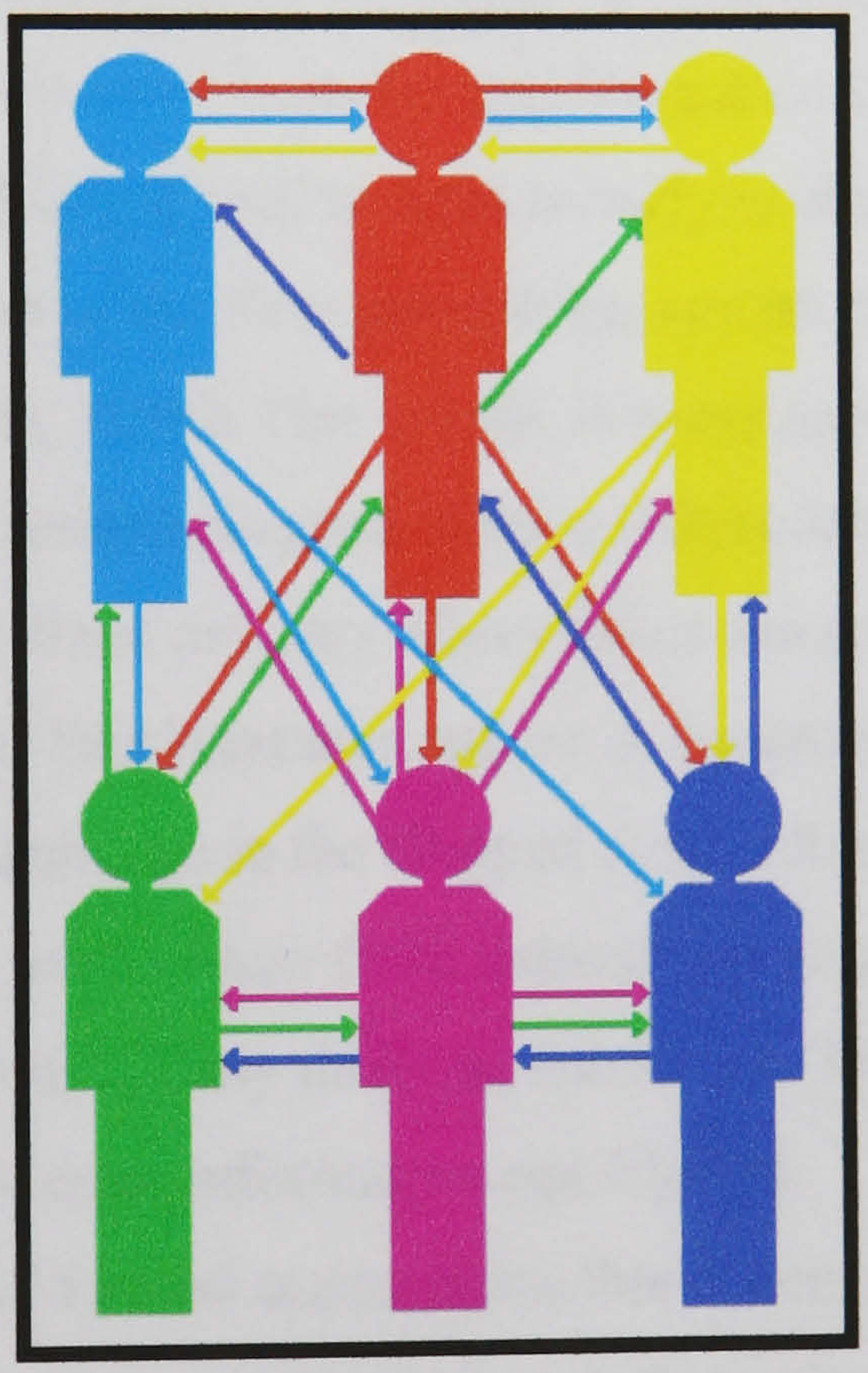


FIGURE 4.16 – This is an abstract representation of the information flow that is indicative of homogeneous system at equilibrium. This represents an idealised situation that has probably never existed in a natural system.

pattern of similarity are indicative of personal or individual independent behaviour. Also, the detection of more than one pattern of similarity in the data is an indication of more than one organisation of information flow.

In terms of social structure this condition would be best illustrated by a highly egalitarian society that maintains small social units in which all members interact with all other members in daily group activities. Typically we envision these groups to contain from 20 to 50 individuals, but rarely over 100 individuals (Redman, 1978; Henry, 1989). On the other hand, this type of information flow could be maintained within groups as large as 150 to 200 individuals and possibly even larger (Dunbar, 1996). It may be possible to determine an upper boundary for the group size within which this type of information flow can be maintained, but such a project is beyond the scope of my current research.

Egalitarian social structures typically place a strong emphasis on inclusive group activity (Turnbull, 1961), but interaction that produces high levels of homogeneous information flow does not require constant participation in group activities. Intermittent participation or even observation of activities is sufficient for nearly complete information flow.

DST demonstrates that systems at or near an equilibrium tend to require relatively long times to move away from the equilibrium condition. This is due to the fact that systems near equilibrium tend to react linearly to changes in input, and they tend to accumulate a portion of the flow through the system at a relatively low level (Prigogine, 1988; Kauffman, 1993). This is seen in many aspects of prehistoric cultures. For example, the earliest chipped stone artefacts date to around 2.5 mya. They are characterised as a basic flake industry where flakes are produced for their sharp edges. At about 1.5 mya the first handaxes appear in the archaeological record. This denotes the first qualitative change in the chipped stone behaviour of our ancestors. In other words, our ancestors used a basic flake industry for about one million years before they changed to a qualitatively different behaviour. This is a good indication that they were functioning at, or near, information equilibrium.

One consequence of a social organisation that is near equilibrium is that the knowledge content of the group is relatively low. Information flows uniformly to all individuals in the group therefore each individual has virtually the same knowledge as every other individual in the group. This results in a condition where the total knowledge of the group is virtually equivalent to the knowledge of any individual in the group (see Figure 4.17).

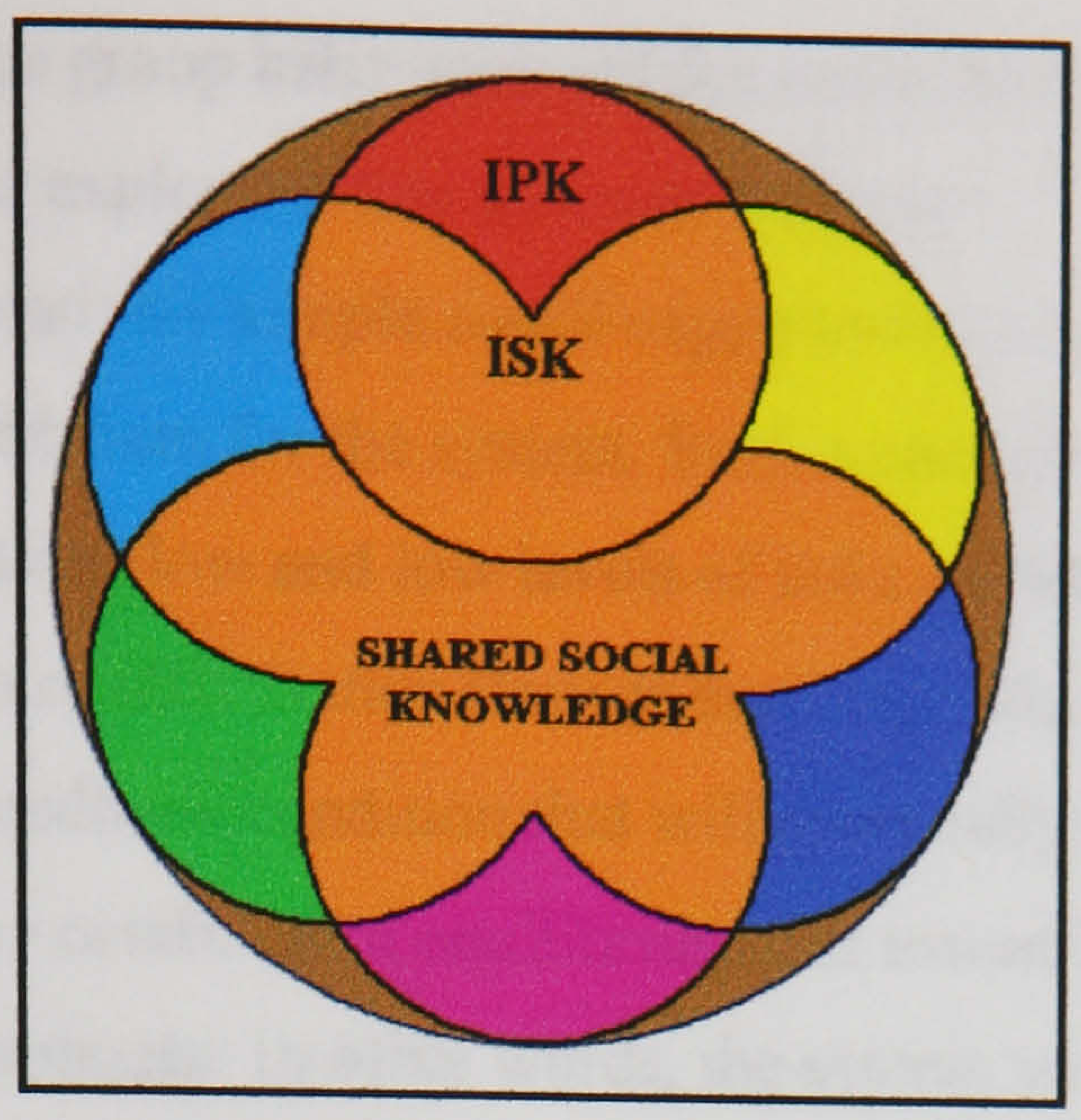


FIGURE 4.17 – A graphical representation of the knowledge contained within a group that is near the state of natural equilibrium shown in Figure 4.16. This figure shows three important aspects of a system at a natural equilibrium, first, the individuals in this group have a great deal of knowledge that is very similar, which is often characterised as *shared social knowledge* (the area coloured orange). Second, the significant knowledge differences between individuals are due primarily to personal knowledge (the area coloured red labelled IPK). Finally, the knowledge of any individual is nearly equivalent to the knowledge of the entire group.

In systems that are near equilibrium the information flows nearly uniformly to all individuals, and this results in a condition where much of an individual's knowledge is very similar to the knowledge of all other individuals in the group. In Figure 4.17 the knowledge systems of the six individuals in this hypothetical group are represented by the overlapping circles. The parts of the circles that do not overlap are in different colours and one is labelled IPK (Individual Personal Knowledge) to indicate that these portions of an individual's knowledge are personal, private, and not generally shared with the group. The overlapping portions of the six circles (coloured orange) are labelled Shared Social Knowledge to indicate that this is the knowledge that is common to every individual of the group due to the nature of the social organisation. An individual's shared knowledge (ISK) would include things that the group does together, such as foraging, food preparation, and tool manufacturing. The IPK would contain knowledge that has to do with aspects of the individual's life that are not constrained by the social organisation of the group. For example, if only one of the members of the group engages in carving bone then a significant amount of the knowledge that is specific to bone carving would be known only to that individual. This is especially significant if the individual engages in this behaviour predominantly at times when they are alone. These types of individual activities (and their resident knowledge) can become integrated into the group behaviour and the social knowledge by a number of mechanisms (too many to explore in this research project).

To summarise, relatively simple social organisation is one that is at or near a condition of natural equilibrium for the system. Such a condition is characterised by undifferentiated information flow and low levels of information accumulation. Increasing differentiation of information flow or increased accumulation of information will result in a positive feedback condition that will eventually move the system farther and farther away from the condition of equilibrium and towards a condition of relatively increasing complexity. In other words, the system will tend to move from a condition of homogeneous information flow to differentiated information flow with time. As an information system becomes more complex it will accumulate information at a greater rate, which will move the system farther and farther from the equilibrium condition.

4.3.05 Social Complexity Far From Equilibrium

DST states that a system at or near equilibrium is in a condition with very little or no structure. In an information system this means that any individual is just as likely to get a specific bit of information as any other individual. In a cultural system this is characteristic of the simple social organisation typical of egalitarian societies. Complex social organisation is a condition where the information flow becomes structured, and some individuals will be much more likely to get certain types of information than other individuals. DST states that a transition from an unstructured condition to a structured condition facilitates information flow. The transition to a structured state also facilitates information accumulation. In an information system either the information flow is forced to increase by external mechanisms or the system accumulates a critical amount of information that results in a reorganisation that produces structure or produces a qualitatively more complex structure. The internal processes that result in a reorganisation to increased complexity are the focus of this research.

There are fundamentally two internal mechanisms that will lead to a critical amount of information accumulation. First, a system will accumulate information until it reaches a critical level where the information will be reorganised into a more efficient network. This is analogous to the formation of Benard Cells in a homogeneous fluid. Second, an aspect of the system may become part of a positive feedback loop that produces a change to the system. Either of these two mechanisms can result in either a qualitative or quantitative change in the organisation of the group. Quantitative changes to the information of the group refers simply to the amount of information available to the group as a whole. A qualitative change to the information of the group refers to the organisation of who has access to what information. At equilibrium everyone has an equivalent potential to access any and all information within the group. The relevant question at this juncture is "How does a structured information flow develop?"

There are a number of processes that typically result in a qualitative reorganisation of the information flow of a social group. One such mechanism is found in the level of information contained in a specific behaviour. As a task becomes more sophisticated the amount of information required to complete the task will increase, and the information associated with the task will become more demanding so that higher levels of competence will be required. This causes a reorganisation of the behaviour patterns and the structure of the information flow of the group. For example, the lithic industry at 2.5 mya was a simple flake industry where flakes were struck from stone for their sharp edges. Almost any one can learn to do this in about twenty minutes. On the other hand the technology for producing a handaxe is much more demanding, and there exists the possibility that not all people will have the abilities and motivation required to learn this level of chipped stone technology. In this case the handaxe might represent a point in chipped stone technology where a differentiation in the social information flow develops. The information flow becomes qualitatively different by the introduction of a structured flow that is focused on chipped stone technology and involves special access to certain information by a limited number of individuals within the group. Those individuals that participate in handaxe making can be seen as having privileged access to handaxe information. An example of another mechanism that can produce structured information flow is provided by the size of the group. As a group grows in size there will become a point where engaging in an activity by the entire group is no longer possible. Reorganisation into multiple sub-groups within the larger group becomes more likely as the group increases in size. When sub-groups form the information flow takes on two levels, one is the continuation of individual-to-individual information flow and the new level is the group-to-group information flow. Once sub-groups form they can diverge from each other with regard to some aspects of behaviour and knowledge. The amount and type of information flow that is maintained between the subgroups will determine how much and what type of divergence can occur.

As a system moves away from its local point of equilibrium the flow of information will first become elaborated and then differentiated, and the amount of information that is accumulated will increase. As information flow becomes elaborated the system will be transformed into increasingly more complex configurations of interaction and patterns of behaviour, which are self-organising and self-reinforcing. Figure 4.18 illustrates a condition of elaborated information flow where a group is comprised of two closely interacting sub-groups.

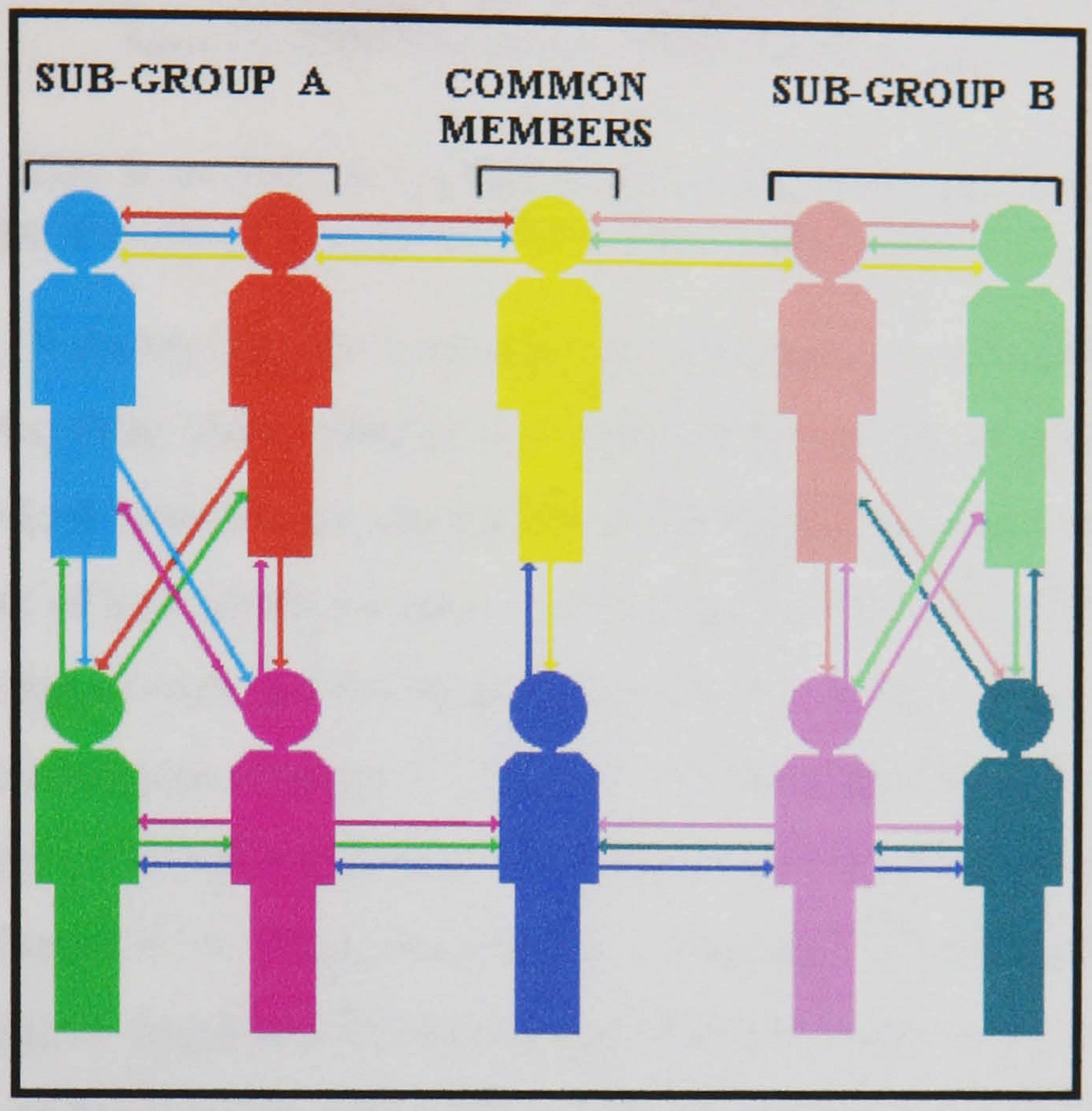


FIGURE 4.18 – This is an abstract representation of an elaborated information flow within a system that has moved away from the absolute equilibrium condition.

In this example the group is comprised of two sub-groups that contain common individuals. In other words two individuals belong to both sub-groups and information flows freely and symmetrically from each of the sub-groups to the other through the common members of the sub-groups. The fact that both sub-groups have individuals in common keeps the information organisation equivalent in both groups. For example, if you speak Spanish and Italian, as well as your native English, and are engaged in archaeological projects in Spain and Italy, then you become a conduit of information flow between the Italian and Spanish archaeologists even if none of them speaks or reads a language other than their native language. As an example of an elaborated egalitarian social organisation this configuration provides for an increase in the amount of information that can be accumulated. In the example, the Spanish Archaeologists have a greater amount of knowledge pertaining to their language and their archaeological institutions than either you or the Italian archaeologists. This is illustrated in Figure 4.19.

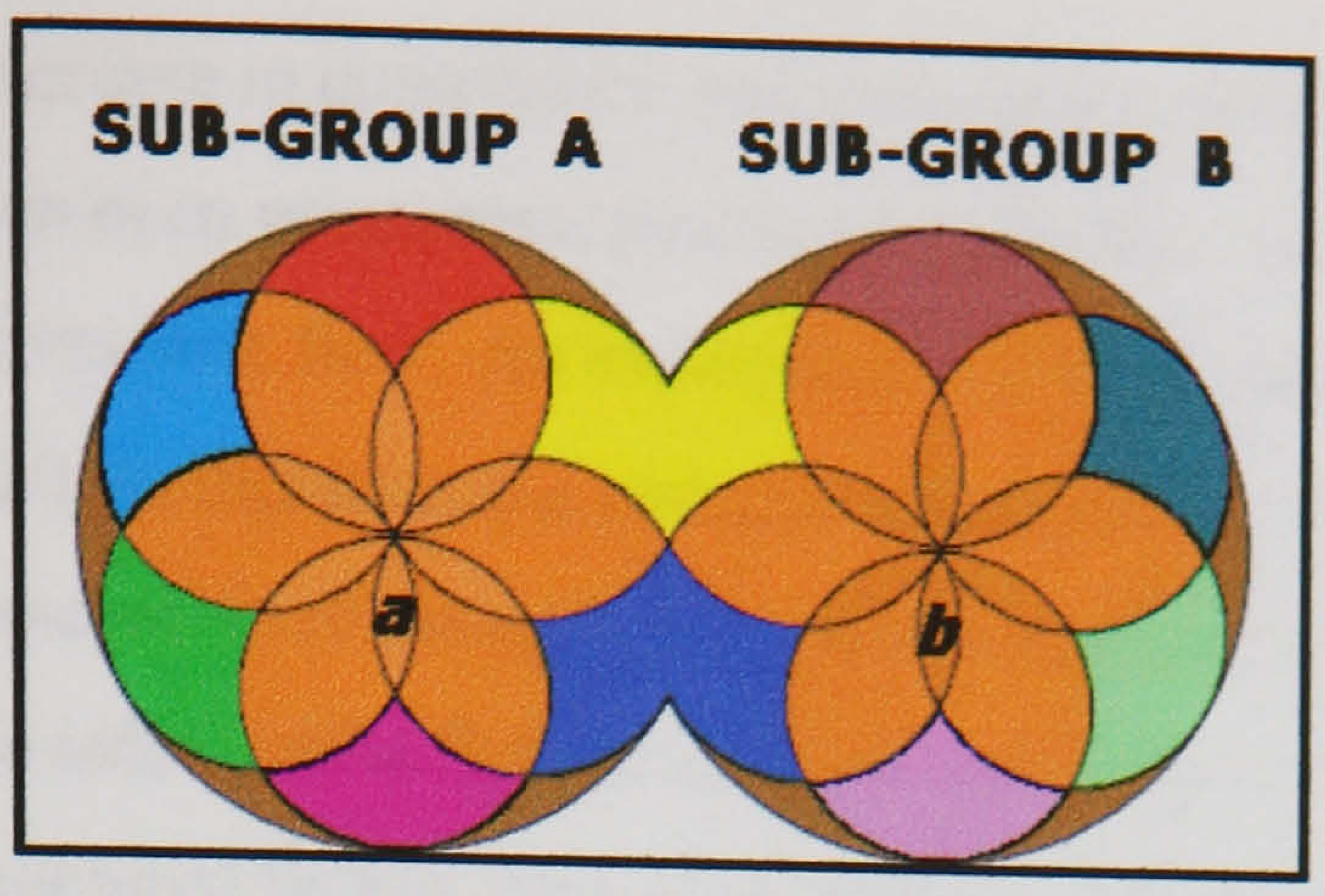


FIGURE 4.19 – This is an abstract representation of the elaborated structure of knowledge in a group as it moves away from equilibrium.

Figure 4.19 shows that the knowledge of this system is potentially larger for a number of reasons. First, the number of individuals in the group is larger therefore the amount of individual knowledge contained in the group can be larger. Second, the expanded number of individuals of the group will tend to allow for an increase in the personal knowledge of each individual due to increased variation of personal knowledge. If you compare Figures 4.17 and 3.19 it is evident that the amount of individual knowledge that is represented by the colours is larger in the elaborated social organisation of Figure 4.19. Third, the socially constrained knowledge of the two sub-groups can be slightly expanded due to slight differences in the sub-groups. Forth, the total knowledge of the group is potentially greater than would be expected by simply adding four individuals to the original group. Fifth, the individuals that are common to both sub-groups represent a conduit through which information flows between the two sub-groups. This information flow will tend to be slightly inefficient and less that 100% of the information will be transmitted. This will tend to increase the amount of information accumulated in the personal knowledge domain of these two individuals, and the less than perfect information transmission between the two sub-groups can result in differences in the social knowledge content. For example, some of the social knowledge of one of the sub-groups will not be part of the social knowledge of the other and will constitute both social and personal knowledge for one or both of the two common individuals. All of these aspects of elaborated information flow combine to produce a condition where the total knowledge of the group can be relatively much greater than the knowledge of any individual within the group and increases the potential difference in knowledge from individual to individual. A significant increase in complexity and knowledge can result from elaborated information flow, but an even greater increase in complexity and knowledge can occur with differentiated information flow.

A significant increase in complexity and knowledge can result from elaborated information flow, but an even greater increase in complexity and knowledge can occur with differentiated information flow. An example of differentiated information flow is presented in Figure 4.20. In this example two groups interact on a relatively frequent basis, but none of the members of Group 1 are members of Group 2 or vice versa. Within both groups the information flow is uniform, but between the two groups the information flow is structured by the form of interaction that occurs between the two groups.

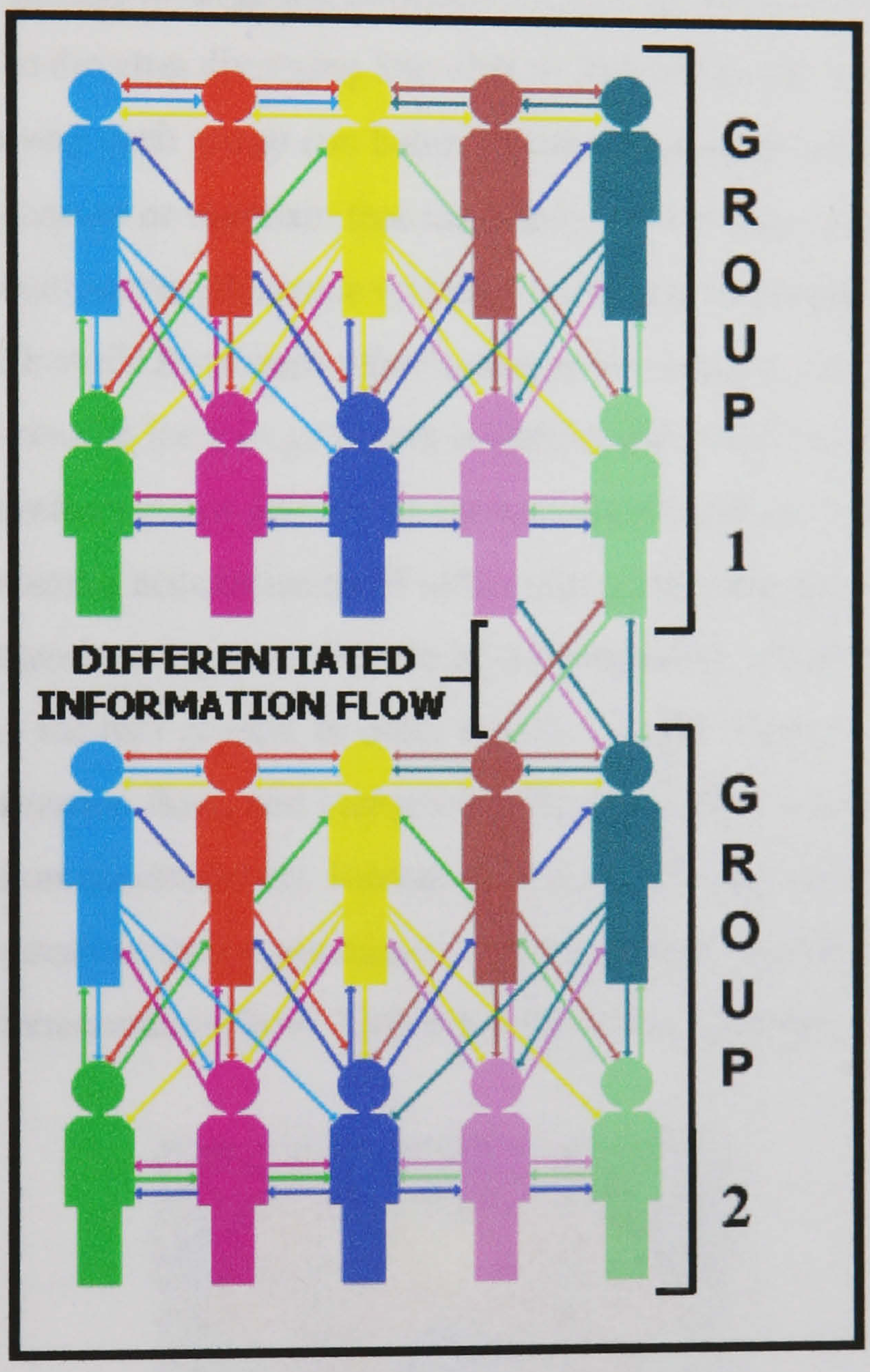


FIGURE 4.20 – This is an abstract representation of the information flow in a differentiated social organisation. All of the information in the combined groups 1 and 2 no longer flows to every individual in both groups.

Figure 4.20 shows one of a large number of social organisations that will result in the differentiation of information flow. The two members of Group 1 that interact with Group 2 will transmit information to the other group and receive information from the other group based on the specifics of their interaction with that group. The type and amount of information that is exchanged will determine how much diversification will occur and which aspects of information and behaviour will diverge between the two groups. In any configuration that represents differentiated information flow, inclusion in a group represents preferential access to the information transmitted within the group and therefore to the knowledge accumulated by the group.

As the social organisation of the two groups becomes more differentiated the amount of knowledge contained in the super-group (consisting of the combined Groups 1 and 2) will tend to increase. Figure 4.21 illustrates this increase in knowledge.

As the two groups diverge the information flow between them will decrease, and they will tend to develop diverging knowledge that will result in differing behaviours. In this way each group can benefit from the other group's knowledge without having to acquire or maintain that knowledge. If the two groups diverge too far their basis for interaction may dissipate and they will cease to interact. In which case they will no longer benefit from each other's unique knowledge. As long as information flow between the two groups is maintained they will continue to self-organise into a cohesive system that has an increased potential for information accumulation. Increasing accumulation of information can become part of a positive feedback loop that tends to increase the rate of differentiation of the information flow within and between the two groups. In other words, cultural systems will tend to increase their information flow, and increased information flow tends to result in increased information accumulation. Increased information accumulation in turn tends to produce transformations in the organisation of the system that tend to result in yet greater amounts of information flow. This is a pattern that continues to spiral upward

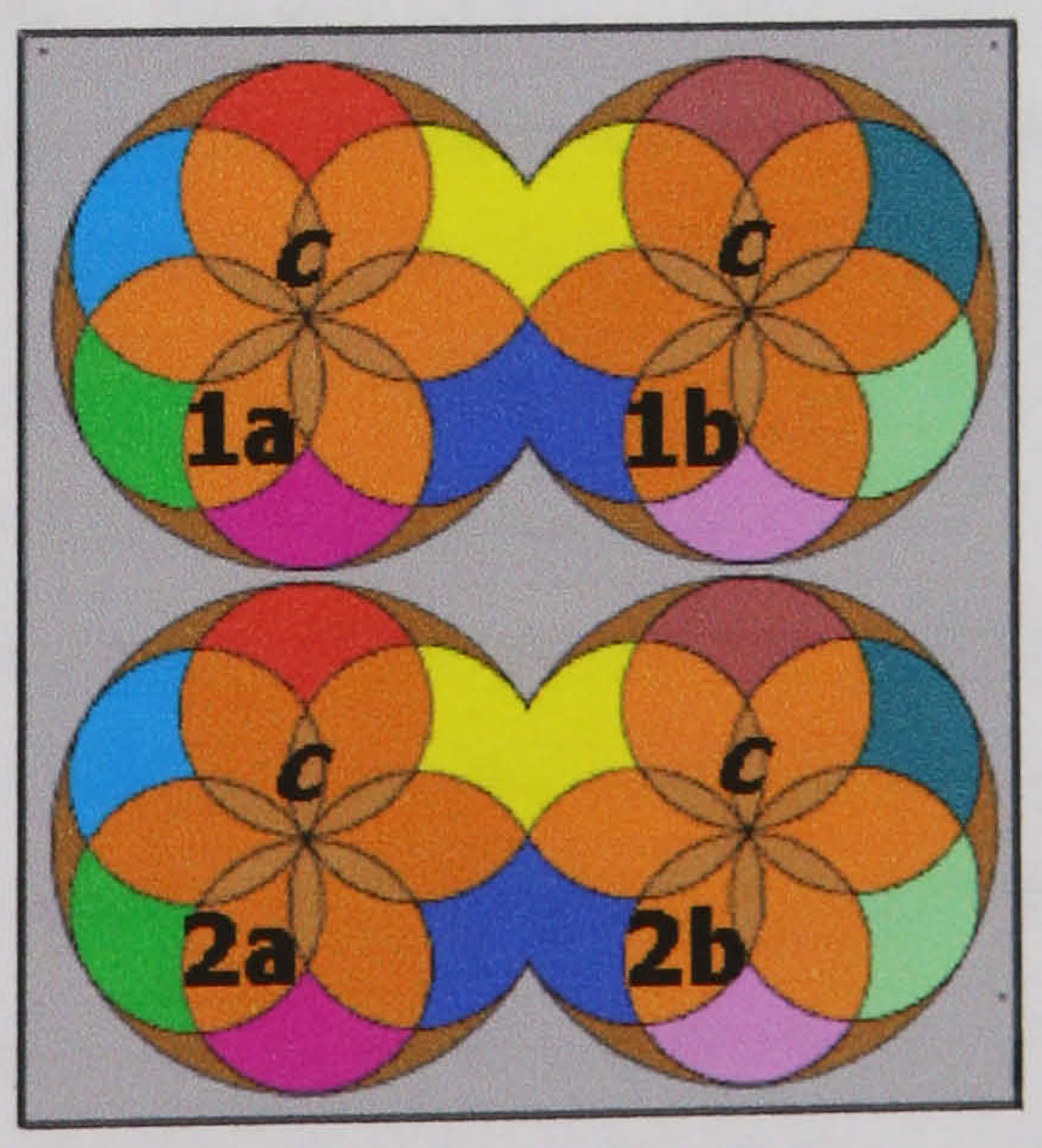


FIGURE 4.21 – This is an abstract representation of the knowledge structure of a differentiated social structure.

causing increased information flow, information accumulation, and system complexity throughout the life of the system. Complex systems are sustained by a flow that increases their complexity or are deprived of a flow, which results in the system collapsing back toward a natural equilibrium. In other words, the principles of DST demonstrate that complex systems either increase in complexity, through the accumulation of a part of the flow, or they collapse due to a lack of flow. A complex system, such as culture, can never reach or maintain a static equilibrium. We can never keep things as they are today or as they were yesterday.

4.4 SUMMARY

Complex-Systems Theory of Culture is a general theory that explains cultural phenomena based on a synthesis of Implicit Learning Theory (ILT) and Dynamical Systems Theory (DST). ILT explains human behaviour as a product of knowledge that is constructed through the process of the detection of structures in the information contained in the environment, which is experienced by the individual. Each individual assigns meanings to these structures based on their unique capabilities, inclinations, and perspectives. From the perspective of ILT the mechanisms of learning are a universal human trait that is capable of detecting patterns of covariation in the stimulus environment, which is described as very rich and complex. These covariations are instantiated in the individual's mind in the form of abstract representations of the structure that is perceived in the environment. This presents the perspective that individuals are autonomous learners, that they construct their knowledge and behaviour based on internal mechanisms, and that ideas and knowledge are not determined by external mechanisms. At this level of discussion each individual is unique, and there is no basis for expecting any two individuals to display similar knowledge or behaviour. The frequently stated observation that cultures appear to function as an integrated whole requires another level of discussion and explanation.

Dynamical Systems Theory (DST) constitutes an explanation of complex systems that are comprised of a large number of autonomous entities (which are usually relatively similar). This perspective provides the context within which the interaction of unique individuals will tend to produce the organised and regular patterns of behaviour and knowledge that can be recognised as cultural entities. DST also provides the foundation for explaining and investigating cultural phenomena such as social organisation, the advent, elaboration, and collapse of cultural complexity, and the patterns of stasis and change that are evident in a historical perspective of cultures.

DST explains complexity based on the non-reversible processes inherent to dissipative systems. A many-bodied dissipative system contains a large number of relatively similar elements that participate in a common flow through the system. Dynamical systems are form by a flow of matter, energy, or information (or any combination of these three), but cultures are fundamentally information systems in which the flow of energy and matter is constrained by the information in the system. Individuals self-organise into coherent collectives in a manner that is consistent with the principles of DST, and cultural phenomena can be discussed as complex systems.

As cultural entities, humans display complex behaviours at two distinct levels of interaction. Humans display complexity as individuals interacting within a specific environment, and they interact with each other to display complexity as coherent collectives. DST provides the framework for explaining and investigating complexity at both of these levels.

Individuals self-organise their knowledge using the learning mechanisms that are explained by ILT. Groups of individuals self-organise into what can be referred to as *conceptual attractors* due to the fact that they participate in a common flow of information. This participation in a common flow of information *shapes* the self-organising process, but it does not *determine* what the individual will know (or how the individual will behave). This results in a condition where individuals within a cultural milieu will tend to have similar knowledge and similar behaviour, but any given individual can diverge dramatically from the typical behaviour and knowledge of the group.

CSTC is a general theory of culture, which means that many of the specifics of cultural phenomena have not been addressed yet. At this level the theory provides a framework for investigating cultural phenomena and for developing more sophisticated and specific theories that will explain the detailed interactions within and between cultures.

CSTC provides a framework for linking information, knowledge, behaviour, and the material components of behaviour. This is important to archaeologists because it provides the foundation for reconstructing past behaviour and knowledge from the information contained in the material record, which is produced by cultural behaviours. For example, social organisation can be inferred from the material components of culture. Cultural groups can be identified by the similarity of the material products of their behaviour. This has been typical common sense approach employed within archaeological research to separate chipped stone artefacts into lithic traditions or lithic industries. When applied to the archaeological record a cultural history or sequence of cultural groups can be reconstructed. This is analogous to the Linnaean classification of species in biology and represents an argument about the structure or organisation of cultural entities. As an explanation of cultural organisation CSTC is analogous to Darwin's theory, which explains the organisation of biological entities. From this perspective CSTC provides an explanation of why the cultural historic methodology has a certain amount of validity, but as an explanation of the organisation of cultural entities it provides the means for investigating social organisation at many levels.

As an example, consider a hypothetical case of social organisation that produces sub-groups within a site and is focused on lithic technology. If lithic technology is involved in a structured social organisation within a site then the information contained in the lithic artefacts should contain some indications of that social structure. A hypothetical case could be in the form of a tool that is commonly used for a task that is part of the site level organisation of social interaction. DST explains that the information flow at this level will tend to constrain the tools produced at the site to be relatively similar. If the tools are produced at the same level of organisation as they are used then the techniques for producing the tools will also be relatively similar for the entire site. On the other hand, if the tools are produced by distinct sub-groups within the social organisation of the site then DST states that each sub-group will diverge to relatively unique techniques even though the end item remains relatively similar. These sub-groups of manufacturing should be identifiable in the lithic artefacts even when they have become mixed due to post-depositional processes. Obviously it would be much easier to detect these sub-groups if the archaeological data indicated discrete units containing the debitage from unique production methods.

CHAPTER 5

DYNAMICAL SYSTEMS THEORY AND ARCHAEOLOGICAL RESEARCH

CHAPTER 5

DYNAMICAL SYSTEMS THEORY AND ARCHAEOLOGICAL RESEARCH

In the chapter on General Systems Theory (GST) the current state of the application of GST to archaeological research was discussed. This theoretical position is dominated by the concept of homeostatic mechanisms within closed systems that manipulate energy and matter. GST models can be very effective within a closed system domain, but many issues in archaeological research focus on transformations in behaviour and the effects of these transformations on the archaeological record. Understanding transformations within a system requires an open-system perspective, and Dynamical Systems Theory (DST) is the most comprehensive explanation of open systems. Although this section will focus on transformations and open systems, it should be obvious that GST issues and mechanisms are contained within this framework, and that this might be considered an inter-theoretic reduction of GST and DST into one theoretical perspective (see Churchland and Churchland, 1995).

This chapter contains several sections, and the first is an overview of some of the aspects of DST that were presented in Chapter 3. The goal is to reveal important aspects of dynamical systems and to present them as powerful conceptual models that can be used to describe systemically the transformations that have been observed in natural phenomena. The concepts presented here were compiled mainly from the works of Kauffman (1993), Lewin (1993), Mainzer (1994), Saviotti (1996), Kelso (1997), and Auyang (1998). This discussion will focus on an abstract conceptual description of Dynamical Systems Theory, and will avoid the advanced mathematics involved, which, I feel, would constitute an unnecessary and irrelevant complication at this level of discussion. The subsequent parts of this chapter contain discussions of specific attempts to introduce DST concepts into anthropological and archaeological thought. The focus of these will be the development of the application of DST within archaeological research.

5.1 DYNAMICAL SYSTEMS THEORY

Dynamical Systems Theory (DST) is concerned with understanding how complex systems function. First, dynamical systems display discontinuous change that is produced by continuous processes. Second, dynamical systems typically contain large numbers of nearly identical elements, and the surface complexity of a system is an emergent property of these elements interacting in relatively simple and deterministic ways. The complexity of the system arises from the indirect effects that elements of the system can have on each other over relatively large portions of the system. These interactions are due to positive feedback amplifications of small changes to the elements of the system. With this conceptual view of dynamical systems as a reference, it is now possible to proceed to a deeper level of discussion. The first task will be to put dynamical systems in a context with other systems. This will begin with a brief discussion of *static systems*.

5.1.01 Static Systems

Some of the aspects of dynamical systems can best be exemplified within a discussion of the three fundamental categories of systems. The first system to be considered is the static system, and an example of such a system would be a shopping list or an organisational chart of personnel in the management structure of a company (Checkland and Scholes, 1990). A shopping list has a structure, but the structure is not necessarily dependent on the relationships between the items on the list. For example, the structure may exist as a function of the chronological order in which the shopper became aware of their needs. On the other hand, an organisational chart does indicate some of the relationships between the elements of the system. An example of a natural static system might be a rock placed on flat ground. These types of natural systems tend to be balanced and near some natural equilibrium, and therefore highly stable and predictable.

5.1.02 Dynamic Systems

Dynamic systems are typically the focus of general systems theory (GST), and are discussed in more detail in Chapter 4. In contrast to static systems, dynamic systems display interactions between the elements of the system, and dynamic systems display changes that correspond to inputs to the system. Typically the changes in dynamic systems are considered to be linear or curvilinear and smooth with respect to the input to the system. A mechanical clock is a typical example used for discussing simple dynamic systems. Dynamic systems have processes that are reversible; the structure of the system is fixed so that the relationships between the elements of the system remain constant as the system functions. Dynamic systems tend to display some form of predictable cumulative change or simple periodic repetition.

An example of a natural dynamic system might be the solar system. Within certain parameters the behaviour of certain aspects of the solar system represent predictable repetitive behaviour. For example, the moon orbits the earth in a highly repetitive behaviour. In the known history of human experience the moon has orbited the earth just as it does today. The moon moves, which makes this a dynamic system, but it returns to the same place periodically to go through a virtually identical set of motions (from our perspective) again and again.

5.1.03 Dynamical Systems

Dynamical systems are distinct from the other categories of systems in that the structure of the system is not fixed and the elements do not maintain constant relationships. The structure of the system is organised by processes of interaction between the elements, and as these interactions change in relationship to each other the structure of the system will periodically change.

Dynamical systems display a broad range of behaviour. Many systems will display relatively long periods of static equilibrium, linear change, or periodically repetitive behaviour before producing their characteristic transformations. The property of dynamical systems that most investigators find interesting is their ability to unexpectedly produce periods of rapid and discontinuous change that often results in a transformation of the system into a new and unpredictable state or configuration. It is this characteristic behaviour that separates dynamical systems from static and dynamic systems, and it is responsible for the traditional view that they are chaotic or without pattern (or structure). This property is best observed in natural systems, and will be discussed in more detail in the section on natural systems. The ensuing discussion will begin will the distinction between open and closed systems.

5.1.04 Open Systems

One of the defining characteristics of all dynamical systems is that they are open systems. This means that the system is always under the influence of a flow of matter, energy, or information through the system. It is the flow through the system that sustains the functioning of the system, and it is the flow through the system that allows the system to transform to qualitatively new and distinct states. As dynamical systems progress through transformations to qualitatively new states they move farther and farther from equilibrium and become more and more complex.

5.1.05 Non-Linear Systems

Nonlinearity is a necessary, but not a sufficient, condition of dynamical systems. The simplest way to understand a non-linear system is that it has a discontinuous output with a continuous input. Water displays this property with respect to phase state changes from solid to liquid and from liquid to gas. At sea level water normally has three possible steady state phases and can be shown to maintain these states over wide ranges of temperature. As increments of heat are added to the system the temperature of the water will increase incrementally in proportion to the heat added until the water reaches the temperature of 100 degrees centigrade. At this point the system will display a discontinuity on two parameters. Its temperature will cease to rise as increments of heat are added and it will change state from a liquid to a gas. This is commonly referred to as a bifurcation. From this perspective the system of water displays non-linear dynamics, but it is not dynamical (Holton and May, 1993). To understand what makes a system dynamical another aspect must be introduced, and the next part will introduce the concept of reversible and irreversible systems.

5.1.06 Non-Reversible Systems

A simple example of a dynamical system is found in a ball that is balanced on top of a round rod (Alligood *et al.*, 1997). In its initial condition the ball, as it is balanced on the rod, represents a dynamical system that is in a state of static equilibrium. There are several parameters that are the determinants of this system. Gravity is exerting a downward force on the ball, and the rod is exerting an equal upward force on the ball. As long as the weight of the ball does not exceed the strength of the rod the system will remain in equilibrium until it is perturbed. The system displays dynamics when it is perturbed in such a way so as to cause the ball to fall from the rod. There are an infinite number of solutions to this condition because there are an infinite number of points around the edge of the rod from which the ball can fall. It is easy to see that the general solution to this system is that the ball will 'fall' from its position of balance on top of the rod, but the specifics of when and where are virtually impossible to predict or calculate. Also it is important to recognise that this system is not reversible. Within the context of the system there is no solution for returning the ball to its initial steady state on top of the rod once it has been perturbed, and there is no way of determining its initial position from any of its later positions or conditions. Only an external incalculable entity can intervene in the system to return the ball to its starting position. The fact that dynamical systems are irreversible is one of the inherent characteristics that distinguish them from complex dynamic systems.

5.1.07 Natural Dynamical Systems

Natural systems have several aspects that may not be obvious from this discussion. First, natural systems can have a very large number of degrees of freedom, which can be expressed as a large number of parameters. For example, the number of parameters of a developing organism is virtually infinite. Each parameter is capable autonomous change, and each parameter is capable of producing changes to the system. Many of the parameters will function at different levels or on different scales, and any number of parameters may become involved in positive feedback loops that result in dramatic amplifications to small changes in the system. This aspect of dynamical systems is typically referred to as 'input sensitivity', and it is discussed as a prominent feature of this type of system (Kauffman, 1993).

5.2 DST IN ARCHAEOLOGICAL RESEARCH

The following is a discussion of Dynamical Systems Theory (DST) in anthropological and archaeological research. Several examples will be discussed with respect to developing DST concepts for application within archaeological research.

5.2.01 The Explanation Of Change

In *Explanation Of Prehistoric Change* Hill (1977) devotes a chapter to *Systems Theory And The Explanation Of Change*. Hill is interested in 'explaining variability and change in human behaviour'. One of his fundamental points is 'that in order to explain change in human (or cultural) behaviour we must know something about what constitutes change'. Hill's goal is to contribute to the understanding of 'the nature and processes of change' and 'to develop a general theoretical framework' to be used to account for cultural change (Hill, 1977: 60). His framework has two fundamental criteria, it must be able to account for change and stability, and it must be able to account for contemporary as well as prehistoric cultural change. Hill reviews three models that employ General Systems Theory (GST) and selects the one that provides the most promising aspects for developing his general framework.

The first two GST examples will not be presented here because they are typical of the ones discussed earlier. The third example will be the focus of this discussion because it is one of the earliest descriptions of a dynamical system to be presented in anthropological/archaeological literature. In his discussion Hill makes a distinction between different types of systems. Some are classified as 'living' systems, such as organisms and societies, and they are distinct from other systems because they are 'open' systems due to the fact that they have inputs, throughputs, and outputs. Within the context of this distinction it is not surprising that he rejects the two 'closed' system models and selects the one 'open' system model for the basis of his framework.

The model that Hill selects is provided by Maruyama (1963). Maruyama describes positive-feed back in complex systems where a small 'initial kick' is amplified and produces extensive and unexpected results. The following excerpt from Maruyama's article is presented by Hill and constitutes the most relevant of the examples from Maruyama that he discusses.

> "Development of a city in an agricultural plain may be understood with the same principle. At the beginning, a large plain is entirely homogeneous as to its potentiality for agriculture. By some chance an ambitious farmer opens a farm at a spot on it. This is the initial kick. Several farmers follow the example and several farms are established. One of the farmers opens a tool shop. Then this tool shop becomes a meeting place of farmers. A food stand is established next

to the tool shop. Gradually a village grows. The village facilitates the marketing of the agricultural products, and more farms flourish around the village. Increased agricultural activity necessitates development of industry in the village, and the village grows into a city." (Maruyama, 1963: 166)

This is a description of a phenomenon that Maruyama asserts has been observed many times. It doesn't explain the specific mechanisms that work to amplify the 'initial kick', but it does constitute a recognisable description of a dynamical process in an open system.

Hill criticises Maruyama's model on two points. First, he feels that it is improbable that a farmer would randomly locate on a homogeneous plain. Second, he feels that the idea of an 'initial kick' is insufficient to account for the other farmers locating near the first (Hill, 1977: 80). Irrespective of these two criticisms Hill concludes that the Maruyama model is essentially adequate for his purposes and proceeds to set up an example that should be useful within archaeological contexts.

5.2.02 Hill's Model And Methodology

Hill's example consists of a hunter-gatherer group that requires 9-15 bushels of seeds per capita per year. The gathering of amaranth seeds contributes 7-10 bushels per capita per year. The gathering of 'other seeds' amounts to 2-5 bushels per capita per year. This is the description of the homeostatic system, and the inclusion of 'other' seeds keeps the system from collapsing when the supply of amaranth is not adequate for all of the needs of the group. The 'other seeds' constitutes a homeostatic mechanism within Hill's example, and, therefore, the 'change' from amaranth seeds to 'other seeds' does not constitute a change to the system by Hill's definition (Hill, 1977).

For an example of system change Hill suggests that population may increase beyond a point that can be dealt with by the normal elements of the system. In other words the minimum requirement of the group grows to 16 or more bushels of seed per capita per year, and the maximum production of the normal elements of the system is only 15 bushels of seeds per capita per year. Hill suggests that it is at this point that new homeostatic controls must be instituted, such as cultivating seed crops or instituting birth control practices (Hill, 1977: 90). The addition of homeostatic mechanism to the system could constitute 'change' to the system according to Hill's definition. Essentially the stabilisation of the system at a new population level based on new subsistence elements or the re-stabilisation of the system at the original population level based on new cultural mechanisms, such as birth control, would constitute a 'change' to the system (Hill, 1977: 90). This is demonstrated by Hill in a hypothetical example.

Hill's detailed example of system change takes his equilibrium model and changes it so that the system now includes the cultivation of domesticated corn. He then proceeds to describe what would be needed to explain this change. He proposes population growth as the reason for this change, and embarks on the processes of verification of this hypothesis within the constraints of his model. First, it would be necessary to demonstrate that the total supply of amaranth and 'other' seeds was not adequate for the new demand and the system must either change or collapse. Second, it would have to be demonstrated that there were no other regularly available elements that could have supplemented the system and maintained homeostatic equilibrium. Third, it would be necessary to demonstrate that corn did meet the demands of the system and act as a homeostatic control. Fourth, it would be necessary to demonstrate that this new arrangement was irreversible and constituted a new system equilibrium. Hill does not address how all of this could be part of a practical application to archaeological or anthropological research.

5.2.03 The Problems With Hill's Model

There are several reasons why Hill's model does not achieve the stated goal:

1. It is not obvious that this model is based on Maruyama's model. Hill did not like Maruyama's 'initial kick' so it is not surprising that he left it out of his model, but none of the elements of Maruyama's model seem to be represented here. Even if you limit it to one transformation, the first farmer leading to a few additional farmers settling nearby, Hill's model lacks the very aspect of positive feedback that he stated was so important about Maruyama's work.
2. This model requires too much specific information for it to be used in archaeology. It requires knowledge of the exact size of the population and distribution of resources available to it. In most cases this would be difficult if not impossible even for ethnographic research.

3. This methodology fails absolutely with the requirement of demonstrating that there are no other regularly available elements that could be used as homeostatic mechanisms. This is an impossible task because any given culture may have a virtually infinite number of elements that may act as homeostatic mechanisms in any given situation. In other words, it could never be established that cultivating corn was the only homeostatic element that could be used as a control mechanism.
4. Hill's model and methodology could potentially be used to demonstrate the type of change that he is interested in. On the other hand, there remains a vast gulf between demonstrating that the appropriate type of change has occurred and explaining the change. The change to Hill's system is not explained because the change to the system is population growth, not the homeostatic control. If Hill's method could work it would only demonstrate or explain the re-establishment of homeostatic equilibrium within the system, not the change to the system.
5. It is clear from his critique of Maruyama's example that Hill does not understand the system that Maruyama is describing. For example, Hill does not believe that a farmer would randomly locate in a virtually homogeneous farming region. The point that Maruyama seems to be making is that the peculiarities of individual preferences cannot be predicted (in DST concepts this represents system sensitivity to small variations). In absolute terms Hill is correct, the farmer's choice is not strictly random. In practical terms the choice is dependent on so many parameters of perception and personality that it is virtually incalculable and unpredictable.

Hill's model is a classic example of how paradigmatic research fails to be self-critical, and a theory based approach could correct for this deficiency.

5.3 INFORMATION AND SOCIAL STRUCTURE

In *The Trouble With Know-It-Alls: Information As A Social And Ecological Resource* Moore (1983) addresses the issues of social power and social structure, and his goal is to deflect archaeological thought from society as an *energy-consuming* organisation to society as an *information-processing* organisation. It is evident from Moore's focus on 'energy consumption' and 'information processing' that he is employing an open system concept of culture that deals with the flow through the system. His concern is that archaeological data will not reveal processes sensitive to flows of information until the appropriate theories are developed (Moore, 1983: 174). He establishes the fact that the decision-making models that have become a powerful tool in archaeology do not consider information processing. He concludes that a new approach is required to capture the cultural effects of information flow. Moore presents some ethnographic examples of information as a structuring aspect of social organisation, and suggests that this might have applications within archaeological research.

5.3.01 Decision-Making Models

Moore begins by presenting a critique of the decision-making models employed by archaeologists to investigate the flows of matter, energy, and information through cultural systems. His criticism of these models focuses on the failure of the systems approach to reveal the logical connection between the individual, the system, and the pathologies of the system as discussed by Friedman (1979). Moore states that 'most investigators have decided to use the abstraction of economic rationality as a conventional and convenient standard' (Moore, 1983: 176). The employment of a rational economic decision-maker produces models of behaviour that are based solely on the flow of matter and energy. In these models the decision-maker is omniscient and unconstrained by information acquisition, verification, or cultural biases; therefore, information cannot play any role in the formation of the social structures these models produce (Moore, 1983: 178). These are powerful tools for modelling ecological and economic behaviour based on the flow of energy or matter, but they contain no information component.

5.3.02 Information Flow And Social Structure

Moore's basic idea is that 'social process is driven by the dynamic characteristics of information flows' (Moore, 1983: 173). In his view the two aspects of social power are the acquisition of social information and the validation of socially acquired information.

Moore presents information as a resource that must be gathered directly from the environment or indirectly through social processes. People do not have instantaneous access to information, access to a complete set of information, or access to perfectly true information. One example presented by Moore is provided by the work of Hans Aldskogius (1969) who investigated the clustering phenomenon of Swedish summer-home communities. These communities tend to cluster around bus terminals, train stations, and hotels. These facilities provide a network of foci from which areas can be easily explored and summer-home locations discovered. The fact that many potential locations that are equally (or even more) desirable are left un-exploited demonstrates that sites are chosen for reasons other than just their appropriateness for use as a summer-home. Moore concludes that the spatial distribution of summer-homes is not dependent on the ecological requirements of summer-homes, but is dependent on the requirements of individual information fields (Moore, 1983: 180).

5.3.03 Application To Archaeological Research

Moore recognises that 'information flows... are not as directly accessible to the archaeologist' as are the flows of energy and matter, but he feels that this concept is worth further development. He begins with Clarke's (1968) perspective that cultural boundaries are merely the result of decreasing interaction and information exchange. Further study along this line is provided by Barth (1969), Hodder (1981), and Wobst (1978), and Moore concludes that cultural boundaries are caused by changes in the types of interaction and the types of information passing through the boundary (Moore, 1983: 181).

A source of cultural differentiation is provided by Johnson's (1978, 1982) concept of information overload. This proposes rapidly increasing costs of monitoring and processing information as the number of information sources increases. It results in either hierarchical or horizontal segregation of the individual's information field. Moore describes hierarchical segregation as the creation of information processing specialists. He presents Steward's (1938) account of a Shoshonean 'talker' as an example of hierarchical segregation. In this example the 'talker' is described as a village headman, and one of his functions is to keep informed about subsistence resources, such as the ripening of plant foods in different localities, and to impart this information to the villagers. Moore points out that in this simple example the information specialist transmits specific types of information, and Johnson's concept will accommodate a large number of specialists arranged on different levels of the hierarchy. The need to identify information specialists represents a qualitatively new type of information, and it is information that has no referent outside the social context (Moore, 1983: 183).

Moore states:

> "The implications of the preceding discussion for interpreting patterning in the archaeological record should be clear enough. The need to validate information and the social position of the source of information has implications for stylistic change, exchange of exotics, and the development of esoteric knowledge." (Moore, 1983: 186)

The implications are strong, but the development of the application for archaeology is weak. For example, the 'summer-home clustering' example has obvious implications for explaining aspects of site location in the archaeological record. Moore does not develop this or even suggest an avenue for proceeding in developing this approach for archaeological research. It is not obvious how archaeological methods could identify information nodes that would be analogous to the bus terminals, train stations, and hotels in Moore's example. There is a large gap between Moore's conceptual heuristic and a practical methodology.

On the other hand, Moore's example of 'summer-home clustering' is an excellent example of the process described in Maruyama's (1963) farmer/city transformation. Moore doesn't make reference to either Hill (1977) or Maruyama (1963), but this development of individual (or private) information fields as a social structuring mechanism does represent a logical development of Hill's work. From this perspective Moore may fall far short of providing a clear DST methodology for an application to archaeological research, but his work does represent a step in that direction.

5.4 INFORMATION FLOW AND CHANGE

In *Information Flows, Flow Structures And The Explanation Of Change In Human Institutions*, Van der Leeuw (1981) becomes one of the first authors to explicitly attempt to bring Dynamical Systems Theory (DST) into the field of archaeology. His interest is 'change as it applies to cultural phenomena', and he is attempting to make some progress in the stated aim of archaeology, 'the study of processes in the past' (Van der Leeuw, 1981: 230). The topics he discusses are 'ways in which we might conceive of change', 'the kinds of phenomena we may monitor in order to study change in the past', and 'the methods and techniques which we may employ for that purpose' (Van der Leeuw, 1981: 230). The aspects of Van der Leeuw's work that will be presented here are his discussion of an important distinction between two kinds of change (reversible and irreversible change). Next, Van der Leeuw's development of the position that information flow is the core of cultural processes will be discussed. Finally, his development of this approach with respect to applications within archaeological research will be discussed.

5.4.01 A Relevant Concept Of Change

Van der Leeuw begins with a discussion of the distinction between reversible and irreversible change. It is never made explicitly clear why this distinction is important, but the implicit concept is that reversible change is just 'change'. Irreversible change, on the other hand, constitutes evolution and is therefore qualitatively distinct from 'change'. This is similar to Hill's (1977) view, discussed above, that the change from amaranth seeds to other seeds does not constitute a 'change' to the system. Another implicit concept that can be inferred from Van der Leeuw's examples is that irreversible change, and therefore, evolution, is based on mechanisms that are internal to the evolving system. In other words, mechanisms that are external to the system can only cause 'change', and mechanisms that are internal to the system are required for 'evolutionary change'.

To develop this topic Van der Leeuw presents traditional intellectual thought as dominated by the view that reversible changes are patterned and predictable, therefore, they are appropriate as a subject of study. On the other hand, irreversible changes are not considered to be patterned, and their chaotic behaviour is not appropriate as a subject of study. A minor intellectual perspective of the Middle Ages, the 'idea of progress', emerges in the Renaissance, and one of its basic concepts is that irreversible changes are patterned and appropriate as a subject of study (Van der

Leeuw, 1981: 231). Van der Leeuw presents Lamarckian and Darwinian theories of organism differentiation as examples of these two intellectual traditions.

Lamarck argues that the environment will stimulate certain activities in an organism, and that the aspects of the organism involved in these activities will grow. Aspects of the organism that are not stimulated will atrophy, and under these conditions of differential use the structures of organisms will differentiate (Van der Leeuw, 1981: 231). The mechanism for differentiation is external to the organism and the changes are produced by a reversible mechanism and constitute a potentially reversible change. The process is potentially reversible because the environment only produces elaboration or reduction to aspects of the organism. It does not contain a mechanism for introducing new aspects to the organism or for disposing of unused aspects of the organism. In contrast, Darwin 'invokes an irreversible mechanism' (mutation) as the basis of the irreversible changes involved in biological evolution. Mutation provides an internal mechanism for adding aspects to or deleting aspects from the organism. From this perspective Lamarck's theory is about 'change', and Darwin's theory is about 'evolution'. Van der Leeuw perceives that this distinction is not generally understood in archaeological research (Van der Leeuw, 1981: 231).

Van der Leeuw describes the condition of archaeological thought as one in which there is an understanding of cultural change as being irreversible, but there is no theoretical position that clarifies the distinction between irreversible change and reversible change. In effect irreversible change is not well conceived as differing from reversible change in archaeology. The archaeological strategy tends to be the employment of organic evolution as an analogy for cultural change, but 'there was...no real explanation for such irreversible change' (Van der Leeuw, 1981: 231). Van der Leeuw contends that this represents a failure within the field of archaeology to express irreversible change and 'prevented a proper development of theories of change and its causes' (Van der Leeuw, 1981: 232). He characterises current archaeological development as a series of closed systems separated by periods of transformation. The closed systems are homeostatic and dominated by reversible processes. These are well developed and continue to be explored, but it is the transitions that remain undeveloped. It is these transitions that are really what we are interested in (Van der Leeuw, 1981: 232). Van der Leeuw concludes that archaeologists 'are quite often still offering reversible changes as explanation for irreversible one[s]', 'are not in a position to offer adequate explanations of irreversible change', and 'are further away from integrating in one and the same conceptual model, explanations of reversible and irreversible change' (Van der Leeuw, 1981: 232-233). It is this conception of change that he attempts to address through the development of an appropriate model. In other words, he is attempting to develop a theory of 'cultural evolution', which by definition must be based on internal mechanisms of irreversible change.

5.4.02 Information Flow

Van der Leeuw begins the development of his model by introducing the concept of 'information processing as the core of cultural structures and structuring' (Van der Leeuw, 1981: 237). The channels of information processing are defined and generated with respect to an internal flow of information (Van der Leeuw, 1981: 237). He presents the view that 'information flows are self-structuring', and the channels of flow are maintained by the flow of information (Van der Leeuw, 1981: 238). In other words, the channels of flow disappear whenever the flow of information ceases (Van der Leeuw, 1981: 238).

Van der Leeuw attempts to apply this concept to societies by turning to a discussion of 'information flow' and 'organisational flow' (Van der Leeuw, 1981: 243). In this conception 'information flows toward the point where there is most of it (and thus toward the point where there is the most organisation), and organisation flows 'from the point where it is generated'.

Van der Leeuw attempts to explain the structuring of information flows by presenting a hypothetical case where individuals are homogeneously dispersed and a situation of maximum entropy exists due to the fact that interaction between individuals is evenly dispersed. This condition is assumed to persist at a low level of interaction until a random disturbance of entropy generates differentials in the interaction pattern (Van der Leeuw, 1981: 245). This disruption of entropy will generate information-processing gradients and directed information flows that are analogous to the structured information channels of social systems.

This is the point at which Van der Leeuw's discussion of information flows and cultural change fails. The abstraction of a homogeneously dispersed cultural system is never brought into the realm of known configurations. For example, an egalitarian social group could be discussed from the perspective of a relatively homogeneous information flow. Within egalitarian societies there is a high level of group inclusion in most aspects of daily activity, and, therefore, all individuals interact relatively equally and share relatively equivalent access to information (Turnbull, 1961). It is difficult to see how this example would fit into Van der Leeuw's abstract model, and since he does not reduce the level of abstraction of his discussion it is not possible to make the connection between conception and application.

5.4.03 Van Der Leeuw's Approach

Van der Leeuw does not develop his position so that applications to archaeological research become accessible from DST concepts. The focus of this failure seems to be that he does not develop or adequately explain statements such as "...information flows toward the point where there is most of it..." (Van der Leeuw, 1981: 243). Information flow and the processes of structuring that result from it are central to the abstract conceptual discussion that he presents, but they are not adequately explained. These are critical concepts for building a practical model for application within archaeological research, but he doesn't address the aspects of human information processing that constitute information flow. Along this same line, he does not provide examples of how information flow produces organisation. This could be a significant deterrent to the model's acceptance by other archaeologists, and may partially explain why it is never used.

5.5 HUMAN ECODYNAMICS

In *Archaeology And The Ecodynamics Of Human-Modified Landscapes* McGlade (1995) is explicitly proposing DST as the basis of a new perspective in archaeological research. His focus is on modelling human-environment interactions, and he refers to this approach as "human ecodynamics". Typically his models involve the flow of energy or matter through the system, and his perspective is dominated by the concept of human-produced instability within the system.

5.5.01 McGlade's Approach

McGlade begins by critiquing the traditional ecological or economic approach to modelling humans in the environment. According to him such models are focused on an evolutionary context that 'privilege concepts such as adaptation and equilibrium'. He attacks the idea of systems in equilibrium as being what leads to the concept of change originating from outside of the system and cites Binford (1983) as a proponent of this concept. Adaptation is typically expressed as an adjustment to the environment through processes such as natural selection. These two concepts are typically combined to provide a basis for an environmental determinism for shaping human societies (McGlade, 1995: 116). McGlade points out that this perspective underestimates 'the way in which groups are active participants in a coevolutionary process with the natural world' (McGlade, 1995).

McGlade introduces DST by suggesting that adaptation should be replaced by the concept of self-organisation (McGlade, 1995: 117). One of the examples that he cites is Touraine's (1977) view that 'society is an agent of its own self-production, and that embedded in this process we encounter unintended and spontaneous social formation'. McGlade continues to discuss aspects of DST to demonstrate how this non-deterministic description of social organisation can be powerfully modelled using DST and non-linear mathematical formulae. The main point of this discussion is to explain that chaos (as exemplified by strange attractors) is globally organised, but locally chaotic. In other words, social phenomena on a large scale appear to have familiar patterns, but at the level of specific individuals or organisations behaviour is unpredictable and often unexpected.

McGlade elaborates on this concept of inherent unpredictability and pursues the idea of instability due to coupled scales of interaction. For example, competition and predation operate at different time scales than do climatic and geological processes. Multiple processes functioning at different scales can cause perturbation to the system. Social systems can be investigated from the perspective of their ability to absorb and use perturbations to the system. An example of this is contained in McGlade's 1990 work on agricultural systems in England. In marginally productive regions the agricultural practices reduced the productivity of the land to the point where they became susceptible to crop fail when climatic fluctuations caused a deterioration in the weather. The time scale of the agricultural processes is roughly years, but the climatic fluctuations operate on the time scale of decades or centuries.

There is no opportunity for interaction between these two time scales except at the point where the agricultural process has deteriorated the land to the point where the natural weather patterns cause the system to fail. This failure has multiple causal factors and they operate at different time scales.

5.5.02 McGlade And Archaeological Research

The goal of McGlade's work appears to be the construction of an argument aimed at establishing DST as an appropriate tool for archaeological research. To achieve this he has focused on powerful models of human ecodynamics that more closely represent the observed behaviour of natural phenomenon. This is a valid goal and at that level McGlade succeeds admirably, but this success does not advance the use of DST in practical applications to archaeological research. He states that these models cannot be used to predict the future configurations of natural phenomena, except at a global and non-specific level. These models do not make explicit the processes that underlie natural phenomena, which would provide some insight to practical explanations of those phenomena. In other words, the models cannot be used to predict the future, explain the past, or make explicit the underlying processes of natural phenomena. They can only be used to demonstrate that DST and non-linear mathematical models more closely approximate the behaviour of natural phenomena than do other methods of modelling.

McGlade appears to confuse the attributes of his models with the attributes of the natural phenomena he is investigating. For example, he quotes Poincare's (1899) definition of *qualitative dynamics* (which is concerned with the discovery of underlying coherent structures which define the long-term behaviour of a dynamical system) and interprets this to mean bifurcation points and attractors. Bifurcation points and attractors are aspects of DST and the non-linear mathematics that are used to create models. In other words, these are abstractions of a conceptual system that can be used to discuss or describe natural phenomena, but natural phenomena are not constructed of bifurcation points and attractors and trajectories. The underlying structures that Poincare' is referring to are the processes of interaction that produce behaviours that can be described as *attractors* and *bifurcation points*.

5.6 CONCLUSION

One of the advantages of Dynamical Systems Theory (DST) relative to General Systems Theory (GST) is that all DST systems can be explained by just one fundamental mechanism. Dynamical Systems Theory is an explanation of the behaviour of open systems, and all open systems are dependent on a flow of matter, energy, or information through the system. In contrast, GST deals with closed systems, and they can be defined from a vast number of mechanisms - each of which may be unique to just one system. Not only does DST provide a means for rendering systems models into more comparable forms it also provides the means for constructing models that retain the essence of the complexity of the system without the necessity of constructing models that are too complicated to be of any utility. A theory of culture that is based on information flow would not need to construct a model that identifies every possible type or path for information flow (as is the methodology in GST). On the contrary, the theory need only specify how information flow produces patterns or structure so that the detected flow can be interpreted.

The discussion of dynamical systems theory presented here is only a superficial survey of the aspects that seem to be most relevant to archaeological research. It should be obvious that DST contains many difficult concepts that are relatively new to scientific endeavours. The implications of this are that DST will be difficult to work with until researchers have spent adequate time becoming familiar with it. My discussion of Hill (1977) demonstrates that he was aware of some aspects of the importance of open systems, but he fails to grasp or at least he fails to capitalise on the significance of the "information flow" concept in cultural systems.

Moore's (1983) discussion of cultural systems explicitly expresses the importance of information flow. More provides some excellent examples of information flow and the structures that can be the result of information flow. Unfortunately Moore's approach is fundamentally a top-down methodology, which means that he starts with a pattern or structure and then argues that it was produced by information flow. A bottom-up methodology would provide a theory of information flow that explains patterns and structures in cultural systems, and provides the means for detecting (or at least inferring) information flow. Moore is probably frustrated in his attempt to produce a theory that would be useful in archaeological research because complex systems are virtually impervious to attempts to reverse engineer their functions, which is what is required when employing a top-down methodology.

Van der Leeuw (1981) explicitly employs concepts from DST, and he explicitly focuses on the importance of information flow for understanding pattern and structure in cultural systems. Van der Leeuw's discussion consists of a number of abstract arguments about information flow and its potential effects in cultural systems, but he never produces a theory that explains how information flow produces cultural patterns. Without such a theory, van der Leeuw's abstract concepts are of very little utility to archaeological research. His perspective provides yet another paradigm, but this perspective has nothing in the way of an obvious tool that can be employed to enhance fieldwork or analysis of archaeological data.

The last example of DST in archaeological research is provided by McGlade (1995). McGlade does not engage the concept of information flow in cultural systems because his concern is in modelling human-environment interactions. He employs non-linear dynamics to explain the collapse of systems, which he attributes to the effects of perturbations to the system and the effects of processes that are operating at different scales. This is a much narrower perspective than the general cultural processes that are engaged by the other examples presented here. This demonstrates that DST is a very versatile tool, and that it is very important to be clear about how DST is being employed and exactly what is the focus of the research in which it is employed.

Some archaeologists have recognised the potential utility of DST and information flow for explaining cultural systems. Some researchers have focused on the flow of matter and/or energy through the system to produce what amounts to an ecological view of cultural change (see McGlade, 1995). On the other hand some researchers have constructed arguments about the importance of information flow and cultural systems (see Moore, 1983; van der Leeuw, 1981). Unfortunately none of this work manages to capitalise on the potential of information flow to provide the foundation of a theory of culture that can explain cultural phenomena and that can be employed as a useful tool in archaeological research.

Dynamical Systems Theory has been applied to archaeological research exclusively within a paradigm methodology. This application of DST means that the researcher can choose any of the many aspects of DST to use as the context to interpret their data. For example, a researcher may interpret a seemingly rapid change in the archaeological record as the result of the non-linear property of complex systems. Another researcher could focus on self-organisation or sensitive dependence. The fact that the researcher sets the context of interpretation means that each analysis will be unique, subjective, untestable, and virtually unrepeatable. My approach is to incorporate DST into a theoretical methodology that explains culture in general terms. A degree of conceptual objectivity is attained by this methodology because the theory provides the context for research and analysis. Working within a theory methodology constrains the researcher to two choices – either use the theory, which constrains the context of research and interpretation, or work outside of the theory, which is the unconstrained condition of the paradigm methodology. One of the advantages of the theory methodology is that all cultural systems and all aspects of cultural systems are viewed in terms of information flow because this is the primary mechanism of DST. This perspective simplifies the approach to research by unifying all cultural phenomena under one general explanatory mechanism. This approach also makes all aspects of culture roughly comparable, which means the researcher does not need two unique methodologies for investigating burials and architecture, for example.

In Chapters 7 and 8 I will attempt to apply my general theory of culture, which is based on Dynamical Systems Theory and Implicit Learning Theory, to archaeological data from the Near East. The general theory (Complex-Systems Theory of Culture) will be used to generate explicit statements about cultural systems that can be applied to the data.

CHAPTER 6

A REVIEW OF THE ARCHAEOLOGICAL RESEARCH IN THE NEAR EAST

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A REVIEW OF THE ARCHAEOLOGICAL RESEARCH IN THE NEAR EAST

The purpose of this review is to assess the present archaeological data for its potential application for demonstrating how a general theory of culture could be useful in archaeological research. Examples that are amenable to investigation from an information processing perspective are given priority. This review is arranged according to: 1) period [Upper Palaeolithic, Epipalaeolithic, Natufian], 2) region, 3) cultural designations [culture, complex, industry...], and 3) site. Also, this review will focus on specific aspects of the archaeological data that pertain to the following: 1) social organisation, 2) palaeoenvironment/palaeoclimate, 3) subsistence, 4) settlement pattern, 5) and technology.

In this review the Near East is presented largely from the perspective of the Southern Levant. This is due to the fact that the research from most of the other parts of the Near East has not kept a pace with and is not comparable to the research from the Southern Levant. The Southern Levant has been intensively and extensively explored and published during the last three decades.

From the perspective of the Complex-Systems Theory of Culture, the origins of agriculture and social complexity in the early Neolithic of the Near East can only be understood from the perspective of the end of the Palaeolithic. This research will focus generally on the Upper Palaeolithic and the Epipalaeolithic, but the Natufian will be assigned a separate section because it will be the major focus of the present research.

6.1 GEOGRAPHY AND CLIMATE

6.1.01 Geography Of The Near East

The Near East encompasses the modern countries of Turkey, Syria, Iraq, Iran, the states of the Arabian Peninsula, Egypt, Israel, Jordan, and Lebanon (Maisels, 1993). This region is bounded by five seas – the Mediterranean Sea, the Black Sea, the Caspian Sea, the Persian Gulf, and the Red Sea (Maisels, 1993). The presence of these seas are significant because they mediate the effects of the largely continental position of the Near East (Maisels, 1993), and the fact that the Near East has the most uninterrupted insolation in the world (Fisher, 1978). This means that these seas make the difference between merely arid and truly desert conditions (Maisels, 1993). This is most evident in the fact that most of the rainfall in the Near East is the product of air masses that move from the west in the winter along the Mediterranean basin from the Atlantic (Maisels, 1993). Without the seas, such as the Mediterranean, to recharge the winter rains there would be little moisture left for the Near East (Fisher, 1978).

Part of the unique geographic setting of the Near East is that it is the only land bridge between Africa, Asia, and Europe (Maisels, 1993). The major landforms are the Taurus Mountains in the North, the Zagros Mountains in the East, the central drainage basin of the Tigris and Euphrates rivers, and the Levant to the West (Redman, 1978).

Some researchers divide the Levant into two phytogeographic environments – the core Mediterranean zone and the more arid "marginal" zone (Bar-Yosef and Belfer-Cohen, 1989). This division can be attributed to the work done by Zohary (1962), and the modern core zone runs along the eastern Mediterranean shore with the more arid zone consisting of the deserts to the east and the South (Gladfelter, 1997). This modern dichotomy is often adopted as an analogy for discussing the climate of the Near East in the Pleistocene (Bar-Yosef and Belfer-Cohen, 1989). The Mediterranean forest is dominated by oak, pistachio, cedar, pine, cypress, olive, laurel and juniper (Gladfelter, 1997).

The southern Levant provides a good example of the variety of geographic settings that is typical of the Near East. Lieberman (1993) explains that the unusually heterogeneous flora and fauna of the Southern Levant is due in part to the variety of geographic landforms in the area. Five major geomorphologic strips (oriented north to south) are arranged from the west to the east, and they are the Mediterranean coastal plain, the central hills, the Jordan Valley, the Transjordan Plateau, and the Syro-Arabian Desert (Lieberman, 1993). This region contains three major plant-geographic zones – the forested Mediterranean, the steppic Irano-Turanian, and the desertic Saharo-Arabian (Lieberman, 1993).

6.1.02 Climate And Palaeo-Climate

The modern climate of the Near East is broadly described as "Mediterranean. Maisels (1993) explains that a "Mediterranean climate" is characterised by a relatively wet winter and a dry summer where precipitation in the winter is typically at least three times as great as precipitation in the summer. The Near East is generally considered to have hot dry summers and mild wet winters (Redman, 1978). This is especially true of the central lowlands where summer temperatures are high and display a broad range, both annually and diurnally (Redman, 1978).

The Near East has a climate that is far from uniform, and significant evidence has been accumulated to indicate that climate varied dramatically from locale to locale in the past. For example, at the peak of the cold dry spell at about 19 to 18 kya the central part of the Levant apparently experienced high levels of groundwater, high spring outflow, and high lake levels. On the other hand, the Sinai and Negev display dramatic erosion and down-cutting during this period (Olszewski and Coinman, 1998).

In the Near East the Upper Palaeolithic began in a relatively humid climate that was evident from about 40 kya to about 25 kya (Gladfelter, 1997). Clark (1984) describes the climate as being generally moist and warm for the Upper Palaeolithic until about 27 kya. Lieberman (1993) outlines a sequence of cool and wet climate from 60 kya to 20 kya, a cool and dry interval from 20 kya to 14.5 kya, and a cool and wet interval from 14.5 kya to 13 kya. These alternations between wet and dry seem to have had the major effect of expanding the Mediterranean zone during the wet intervals without much change to the faunal or floral composition of the Mediterranean environment (Lieberman, 1993). A another view of climate in the Near East is that it was cool and dry from about 26 kya to about 15 kya, there was an interval of warmer and moister conditions from about 15 kya to about 11 kya, and another interval of cooler dry conditions that are associated with the Younger-Dryas from about 11 kya to 10.3 kya (Baruch and Bottema, 1991; Goldberg, 1994; Leroi-Gourhan, 1995 [from Olszewski and Coinman, 1998]).

In the Near East climate reconstruction is dominated by Palynological and geomorphological studies (Gilead, 1995). Reconstructing past climates is a particularly tricky endeavour. One of the criticisms of this type of work is that organisms don't inhabit climates or environments, but rather, they utilise resources at a fine grained scale that is not typically captured in general climate or environment categories (see Flannery, 1968). Another criticism of climate reconstructions is their inability to separate local variation from regional trends (Gladfelter, 1997).

Pollen data indicate that the vegetation in the Levant contained a substantial amount of oak during most of the last glacial, which stands in contrast to the Zagros region (Niklewski and van Zeist, 1970 [from H. E. Wright, 1993]). On the other hand, all areas of the Near East apparently experience an abrupt increase in oak and other trees just before 10,080 B. P. (Baruch and Bottema, 1991 [from H. E. Wright, 1993]). The oak pollen curve is considered as a proxy for the amount of precipitation in a region (H. E. Wright, 1993). In the Near East the pollen diagrams suffer from a paucity of radiocarbon dates. For example, the work by Tsukada has only two dates to control the interval between 16,250 and 9,770 B. P., and the timing of events on the diagram between these two dates is established by interpolation (H. E. Wright, 1993). The second Huleh pollen diagram published by Baruch and Bottema (1991) has a similar paucity of radiocarbon dates between 17,140 and 11,540 B. P. (H. E. Wright, 1993). On the other hand, more radiocarbon dates may not relieve the interpolation problem. There is a well-established "radiocarbon plateau" problem for the critical interval between 12,500 and 9,500 B. P. (H. E. Wright, 1993).

6.2 THE UPPER PALAEOLOLITHIC OF THE NEAR EAST

The Upper Palaeolithic in the Near East is broadly similar to the Upper Palaeolithic of Europe. In the Levant this is evident in the fact that one of the distinct lithic assemblages is designated "Levantine Aurignacian", which indicates its similarity to the Aurignacian of the Upper Palaeolithic of Europe. In the Zagros Mountains the local variant of the Aurignacian-type is designated the "Baradostian" (Bender, 1975). The research in the Upper Palaeolithic of the Near East has not been uniform, and the last three decades has seen a preponderance of the research being conducted in the Levant (especially the Southern Levant). For this reason, the Upper Palaeolithic of the Near East will be presented largely from the perspective of the Levantine research.

6.2.01 Chronology

The Upper Palaeolithic here refers to the material that dates from about 45 kya until 20 kya, which includes the Middle to Upper Palaeolithic transition. Most researchers state that the beginning of the Upper Palaeolithic is around 47 to 45 kya, but there appears to be two views about the end of the Upper Palaeolithic. On the one hand, some researchers place the end of the Upper Palaeolithic at about 20 kya (e.g. Byrd, 1998). On the other hand there are a number of researchers that include the Epipalaeolithic as part of the Upper Palaeolithic, and they typically place the boundary at the at the beginning of the Neolithic (see Bar-Yosef, 1980). I will deal with the Epipalaeolithic as a separate entity, which is why this review of the Upper Palaeolithic will only include the material that is between 47 kya and 20 kya.

The transition from the Middle Palaeolithic to the Upper Palaeolithic presents some problems for defining the chronological boundary of this entity. In Redman's (1978) review of the Upper Palaeolithic he presents what was then the accepted view, which is that there was a gap in the archaeological record that represented an abandonment of the Near East. In this view the Middle Palaeolithic ended about 45-40 kya and the Upper Palaeolithic began about 35 kya. This perspective was based on negative evidence. Most caves and rockshelters display evidence of an erosional episode between their Middle and Upper Palaeolithic deposits (Clark and Lindly, 1990). Researchers such as Redman interpreted this as both a stratigraphical and a cultural separation that could be explained as a period of abandonment of the Near East.

Research at sites such as Boker Tachtit and Ksar Akil has provided examples of transitional assemblages that fill the gap between the Middle and Upper Palaeolithic (Clark, 1984). Bergman (1990) states that there are at least five sites in Lebanon that have produced material that is comparable to some of the assemblages at Ksar Akil. For example, Antelias Cave (levels V-VII) and Abu Halka (levels IV e-f) have produced assemblages that are similar to those in levels XXV-XXI/XX at Ksar Akil (Bergman, 1990). The transitional assemblages at Boker Tachtit are radiocarbon dated to ca. 47,000-45,000 BP (Clark, 1984), which fits well with the traditional view of the Middle Palaeolithic end at about 45 kya.

Defining the end of the Upper Palaeolithic is complicated by the inclusion or exclusion of the Epipalaeolithic. The interval from about 20 kya to about 10 kya is commonly referred to as the Epipalaeolithic in the Levant (Goring-Morris, 1990 [see also Byrd, 1998]), and this convention will be employed in the present research.

6.2.02 Context

The Upper Palaeolithic in the Near East is broadly similar to the Upper Palaeolithic of Europe. In the Levant this is evident in the fact that one of the distinct lithic assemblages is designated the "Levantine Aurignacian". In the Zagros Mountains the local variant of the Aurignacian-type is designated the "Baradostian" (Bender, 1975). The research in the Upper Palaeolithic of the Near East has not been uniform, and the last three decades has seen a preponderance of the research being conducted in the Levant (especially the Southern Levant). For this reason, the Upper Palaeolithic of the Near East will be presented from the perspective of the Levantine research.

The Upper Palaeolithic in the Near East shares a number of similarities with the Upper Palaeolithic in Europe. Both entities display an evolved blade technology in the production of lithics (Bar-Yosef, 1995). There is also an increase in bone and antler tools, increased use of groundstone tools, and an emphasis on art objects (Bar-Yosef, 1995). There is also a transition from Archaic Homo sapiens to Morphologically Modern Humans that is evident in both Europe and the Near East that marks the transition from the Middle Palaeolithic to the Upper Palaeolithic (Clark and Lindly, 1990).

6.2.03 Methodology

Any discussion of the Near East as an integrated entity is fundamentally problematical. There is an East-West divide in the research that presents the Zagros Mountains and the Levant as distinct entities. At a more local scale there is a North-South divide in the Levant. Bergman (1990) states that the recent input of high quality information from the sites in Israel and Jordan has not been matched in the North. For example, Turkey remains largely unknown, very little has been published from Syria since the 1930's, and research in Lebanon may be halted for an indefinite period (Bergman, 1990). A limited perspective will dominate our knowledge of the Upper Palaeolithic of the Near East until research in other regions of the Near East become comparable with research in the Southern Levant.

Another methodological issue is provided by the change in research focus from a site perspective to a regional perspective. Early research in the Near East by prehistorians such as Garrod (e.g. 1929 and 1932), Turville-Petre (e.g. 1932), and Neuville (e.g. 1934) focused on the deep deposits of caves and rockshelters (Olszewski and Coinman, 1998). These sites provided long sequences of stratified change that was typically interpreted as a unilinear development of chipped stone industries that represented "cultures" (Olszewski and Coinman, 1998).

The change in focus in the Near East can be seen in the tradition of regional survey research that is evident as early as the 1950s (Clark and Lindly, 1990: 164). This approach allows researchers to function in a broader context where sites are not just isolated entities. Settlement pattern research is one of the benefits of this approach, and the dichotomy between circulating and radiating settlement/subsistence strategies has become one of the dominant discussions of the Upper Palaeolithic in the Near East (Clark and Lindly, 1990: 164). In a radiating pattern the residential mobility is relatively low and a number of less intensively used sites, possibly for special purpose activities, should be found locally adjacent to an intensively used base camp. In contrast, residential mobility in a circulating strategy is relatively high, and few, if any special purpose sites should be found in adjacent areas. Intensive surveys of local geographical areas are essential for locating and evaluating the site type and distribution for distinguishing between radiating and circulating settlement/subsistence strategies.

Issues based on estimations of site numbers, locations, and types appear to have been significantly affected by changes in methodology employed by early researchers compared to recent researchers. For example, early research focused on cave and rock shelter sites in the core Mediterranean zone, and was used to construct a unilinear cultural succession for the Upper Palaeolithic in the Levant (Bergman, 1990b: 223; Gilead, 1995: 124). Gilead implies that this may be partly due to site visibility.

> "The continuous and extensive occupation during the recent millennia probably obliterated many Upper Palaeolithic open-air sites in the less arid parts of the Levant." (Gilead, 1995: 124)

Cave sites were easy to find, and contained rich stratified deposits. Gilead suggests that the aspects of the archaeological material encountered by early researchers shaped their perspectives and research questions.

> "…relatively thick deposits of caves and rockshelters…were disturbed by later settlers and by natural post-occupational modifications. This prevented studies of behaviour since 'living floors' were not (or could not be) defined."
> (Gilead, 1995: 124)

More recent research in the Levant typically employed extensive systematic survey, which attempts to locate all the sites in an area that are visible on the surface of the land (Olszewski and Coinman, 1998: 178). The rationale behind this methodology is the researcher's interest in behaviour and how the relationships of sites can inform this topic, and less emphasis on constructing a cultural history (Olszewski and Coinman, 1998: 178).

Another aspect of recent research that differs from early research is that its focus is in the arid and semi-arid regions of the Levant (Gilead, 1995: 124). Gilead suggests that this change in focus affects the visibility of open-air sites. In the core Mediterranean areas of the Levant many open-air Upper Palaeolithic sites were obliterated by the continuous and extensive occupation of these areas (Gilead, 1995). On the Other hand, the open-air sites in the more arid zones have hardly been affected by subsequent human activities due to the low level of occupation (Gilead, 1995). The open-air sites may have survived at a significantly higher rate, but they are not comparable to the sites that survived in the core area. For example, the sites in the core area are deeply stratified cave and rockshelter sites, and the sites in the arid zones tend to be comprised of completely deflated cultural deposits (Coinman, Clark, and Lindly, 1988: 101). Some of the open-air sites in the arid zones are not deflated and were covered a very short time after abandonment (Gilead, 1995). These sites provide data that is conducive to the study of past behaviour through reconstructing the activities on living surfaces (Gilead, 1995).

Some research has been directed at mediating the methodological differences that constitutes the dichotomy of early research in the Mediterranean zone and recent research in the marginal zones. This is in the form of four aspects of research in the core Mediterranean zone of the Levant (Olszewski and Coinman, 1998: 178). Some effort has been made to re-excavate a portion of the deposits at some of the caves and rockshelters using methodologies that are generally comparable to those currently used in the arid zones (Olszewski and Coinman, 1998: 178). A second aspect of research involves the assessment of chipped stone assemblages from the Mediterranean cave and rockshelter sites by re-examining the existing collections from these sites (Olszewski and Coinman, 1998: 178). A third aspect of research is to systematically survey portions of the coastal region (e.g. Bar-Yosef, 1970) (Olszewski and Coinman, 1998: 178). The final aspect of research that tends to mediate the dichotomy between the Mediterranean and the arid zones is provided by the excavations in recently located cave, rockshelter, and open-air sites in the Mediterranean zone (Olszewski and Coinman, 1998: 178).

6.2.04 Upper Palaeolithic Transition

A number of issues are pertinent to a discussion of the transition to the Upper Palaeolithic. These issues will be presented from the perspective provided by the change from a simple linear transition that seemed straightforward to a more complicated transition that seems to be emerging with the increase in data that has been produced by the research since the 1970's.

An example of the changing perspective is provided by comparing the view provided by Redman (1978) to that of Clark and Lindly (1990). Redman claims that 'the boundary between the Middle and Upper Palaeolithic represents major changes in human lifeways' (Redman, 1978: 58). Clark and Lindly acknowledge this traditional view, which includes a biological transition (from archaic *Homo sapiens* [AHS] to Morphologically Modern Humans [MMH]) and the archaeological transition from the Middle to the Upper Palaeolithic. Their position is that the proposed link between these two transitions is poorly documented and that all the data should be considered when discussing this period of transition. In their view, the archaeological data represents clear evidence for cultural and behavioural continuity through this period of transition, especially in the Levant.

The traditional view presented by Redman (1978) was based on the evidence from caves and rockshelters, which had experienced an erosional event at the end of the Middle Palaeolithic. These sites display a clear separation between Mousterian assemblages (which were generally perceived to be associated with AHS) and Upper Palaeolithic blade assemblages (which were typically attributed to MMH) (Gilead, 1995). This separation between cultural entities was typically interpreted as a hiatus in the occupation of the Near East, and the reoccupation was assumed to be by modern humans with a generally more sophisticated behavioural repertoire, which was evident in the new lithic technology.

More recent research has demonstrated that a number of sites contain transitional assemblages that establish continuity in occupation and cultural change in the Near East. Bar-Yosef (1995) states that there were two transitional industries – one that is represented by sites in Lebanon, such as Ksar Akil, and another that is represented by sites in the Negev, such as Boker Tachtit. Bar-Yosef (1980) stated that the transitional assemblages from Boker Tachtit display the manufacture of both Upper Palaeolithic blades and Levallois-style points from the same blade cores. This view is considerably more complicated than the traditional view of the 1970's.

With respect to the biological transition Clark and Lindly (1990) cite the work by Trinkaus (1984 and 1986), which emphasises a functional perspective and interprets the AHS/MMH transition in Southwest Asia to be an *in situ* phenomenon. Clark and Lindly note that this interpretation is in contradiction of the interpretation of the mtDNA evidence by Cann *et al.* (1987). Clark and Lindly present the Trinkaus analysis that relates anatomical changes to changes in selective pressures that are viewed as responses to changes in behaviour. This perspective is based on five morphological complexes; postcranial robusticity, limb proportions, the anterior dentition, the midfacial skeleton, and the neurocranium. The same trends in morphological change are documented for both Europe and western Asia during this transitional period (Clark and Lindly, 1990). These morphological changes are frequently attributed to behavioural changes that are linked to technological advances that require less strength and endurance. Clark and Lindly (1990) reject this explanation by pointing out that there is no correlation between kinds of hominids and associated archaeological industries.

Gilead (1995) presents the position that it is generally assumed that morphologically modern humans were responsible for the Middle to Upper Palaeolithic transition, but the scarcity of human remains in the Early Upper Palaeolithic of the Near East obscures the identity of the populations responsible for these assemblages (Gilead, 1995). In the Levantine Upper Palaeolithic there is only one well-preserved and relatively intact published burial (from Ein Gev 1), but it is dated to ca. 24 kya. The fact that the Ein Gev 1 burial is clearly a morphologically modern human is trivial due to its late date. Clark and Lindly (1990) describe the "linkage" between the biological and archaeological transition to the Upper Palaeolithic as "poorly documented empirically".

6.2.05 Chipped Stone Production

Research on prehistoric material has typically relied on typological classification and ordering of chipped stone assemblages to construct recognisable cultural entities (Gilead, 1995). Rene Neuville (1934) was the first to reconstruct a cultural succession for the Upper Palaeolithic. Neuville's classical sequence, consisting of six successive phases, provided the framework for the early work in the Levantine Upper Palaeolithic (Gilead, 1995).

This traditional approach was used by Redman (1978) to distinguish Upper Palaeolithic assemblages from Middle Palaeolithic assemblages in the Near East. The blade technology that became evident at relatively low rates in the Middle Palaeolithic assemblages dominates the tool production of Upper Palaeolithic assemblages. Redman continues by interpreting blade industries as "...a major technological advance, in terms of both manufacturing skill and the ability to produce more specialised implements" (Redman, 1978). Implicit in Redman's perspective is the distinction between flakes that fit an arbitrary description that constitutes a 'blade' category and 'blade technology' that focuses on the production of blades from blade cores. From this perspective Redman presents a fairly straightforward comparison between the transition to the Upper Palaeolithic in the Near East and in Western Europe (Redman, 1978). One of the distinctions between the Upper Palaeolithic in the Near East and Europe is that nothing comparable to the spectacular tools of the Solutrean period in France has been discovered in the Near East (Redman, 1978: 59).

Lithic analysis in the Near East has made a significant attempt to involve the lithic data in its entirety. Aspects of analysis often include 'retouched pieces, tool forms, debitage, metrical and raw material characteristics, and reduction sequences' (Clark and Lindly, 1990: 165). This approach not only assesses change and similarity synchronically and diachronically, but it also addresses the underlying processes involved in lithic production that are often unchanging in the face of significant changes in the appearance of the lithics.

The early research in the Mediterranean core of the Levant resulted in a unilinear succession that could not account for the amount of variation that became evident in later research (Gilead, 1995). Gilead (1981) and Marks (1981) both developed a bi-linear model of lithic technology for the Upper Palaeolithic of the Levant (Clark, 1984). The Levantine Aurignacian and the Ahmarian overlap to some extent in space and time, but they were described as distinct traditions (Clark, 1984). Gilead (1995: 130, 1990: 177) states that both the Aurignacian and the Ahmarian coexisted from at least 32,000-30,000 BP throughout the Upper Palaeolithic.

The Ahmarian has been relatively well dated to between 41-38,000 BP, and 17,000 BP (Clark, 1984). The Ahmarian is found mainly in the Negev, and it is thought to be an adaptation to an open grassland, steppe and desert regime (Clark, 1984: 84). Coinman presents a general description of the Ahmarian in the following statement:

> "The Ahmarian is currently recognised as a well-developed blade technology, dominated by the production of blades and small bladelet tools, many of which are retouched, backed, or pointed (Gilead 1981a, 1989, 1991; Marks 1981; Marks and Ferring 1988). Traditional Upper Palaeolithic tools, such as endscrapers and burins, occur but are suggested to be less frequent than in Levantine Aurignacian assemblages." (Coinman, 1998: 40)

The Levantine Aurignacian is described by Gilead as consisting of "numerous blank flakes and numerous endscrapers, sometimes Aurignacian, and burins" (Gilead, 1995: 130). The Levantine Aurignacian was initially defined on the basis of cave and rockshelter sites in Lebanon, Syria, and Northern Israel (Coinman, 1998: 40). Featuring strong similarities to the European Aurignacian (see Neuville, 1934; Garrod, 1953; Belfer-Cohen and Bar-Yosef, 1981; Bar-Yosef and Belfer-Cohen, 1988; and Belfer-Cohen, 1995). The Levantine Aurignacian was originally conceived to consist of tools such as endscrapers and burins, especially "Aurignacian", Carinated, and nosed varieties (Coinman, 1998: 40). The core reduction was predominantly a flake industry with low proportions of blades and bladelets (see Neuville, 1951; Garrod, 1954; Hours, 1974; Copeland, 1975; and Gilead, 1991) (Coinman, 1998: 40). The Levantine Aurignacian is typically associated with the Mediterranean Phytogeographic zones (Gilead, 1981; Clark, 1984: 84). From this perspective the Levantine Aurignacian is seen as an adaptation to 'verdant, more heavily forested zones' (Clark, 1984: 84).

It is not clear that this two-model system is adequate. First, the Levantine Aurignacian now encompasses a significantly greater amount of variability than when it was initially defined (Coinman, 1998: 40). For example, some lithic assemblages from the Negev have been identified as Levantine Aurignacian even though they display a relatively poor blade technology with large, thick blades and they lack a true bladelet technology (see Marks, 1976; Marks and Ferring, 1988: and

Gilead, 1991) (Coinman, 1998: 40). Coinman suggests that some of these assemblages have been attributed to the Levantine Aurignacian only because it is the only recognised alternative to the Ahmarian (Coinman, 1998: 40). Coinman (1998) states that only some of the assemblages in Jordan approximate the Ahmarian as described and then not strictly. Coinman continues by stating that few of the Jordanian assemblages appear to represent the Levantine Aurignacian as originally defined (Coinman, 1998: 55). Coinman's perspective is that the Jordanian assemblages are "overwhelmingly blade-based technologies", and they "appear to represent long-term technological continuity" (Coinman, 1998: 55). This level of variation seems to warrant a reassessment of the Levantine models for the Upper Palaeolithic (Coinman, 1998: 39).

Not all researchers are convinced by the Levantine Aurignacian/Ahmarian model. Goring-Morris once accepted the essentially dendritic view of Levantine lithics, but he has more recently reverted back to an essentially unilinear view (Goring-Morris, 1987). Goring-Morris argues for a progression from a blade/bladelet technology, through flake dominated industries, and eventually resulting in a bladelet technology towards the beginning of the Epipalaeolithic (Goring-Morris, 1987).

6.2.06 Bone Tool Production

One aspect of the Upper Palaeolithic that distinguishes it from the Middle Palaeolithic is the significant increase in technological sophistication that is partially due to the increase in bone tools (Bender, 1975). Gilead declares the bone tools to be the most important contribution that is made in the Upper Palaeolithic to the repertoire of artefacts (Gilead, 1995: 133). Gilead's perspective is that in the Upper Palaeolithic bone tools first attain the status of a standardised industry (see also Bergman, 1990a: 207).

The distribution of bone tools is variable, but they tend to be most common in the caves of the Mediterranean zone (Gilead, 1995: 134). For example, the largest assemblage is from Hayonim Cave (layer D) and consists of 75 items (Gilead, 1995: 134). The paucity of bone tools outside of the Mediterranean core may be due to poor preservation (Gilead, 1995).

Bone tools include points, awls, polishers, spatulas, incised fragments, worked antler, and perforated teeth (Gilead, 1995: 134). The bone tools from the

Upper Palaeolithic of the Levant are not as well developed, neither typologically nor technologically, as those found in Europe from this time (Gilead, 1995: 134).

Bone tools have been largely associated with the Levantine Aurignacian, but the only example of a typical European Aurignacian bone tool, the base-split point, comes from the Ahmarian context at El Quseir D (Gilead, 1995: 134). Bone preservation is typically poor at Ahmarian sites, which are generally located in the arid zone, but at Abu Noshra II (where bone preservation is better) a bone point has been recovered (Gilead, 1995: 134).

6.2.07 Burials

The number of burials in the Upper Palaeolithic is very low, especially in comparison to the Middle Palaeolithic (Gilead, 1995: 136). The only well-preserved and published example of a Levantine Upper Palaeolithic burial (prior to 20 kya) is from Nahal Ein Gev 1 (Gilead, 1995: 136). This burial is described as a female, 30-35 years of age, and 1.56 to 1.58 meters in height (Gilead, 1995: 136). The body was placed on its right side, and the legs were strongly flexed towards the head (Gilead, 1995: 136). The tightly flexed position is common among Natufian burials, but it is not known if the position has any significance.

Ronen (1975) suggests that the scarcity of Upper Palaeolithic burials is not due to bad preservation. Ronen suggests that scarcity of burials is an indication that burial at habitation sites was not common. Gilead suggests that there may be a simple functional explanation for this scarcity of burials at habitation sites. The scarcity of burials in the Upper Palaeolithic may be another indication of the ephemeral nature of these sites (Gilead, 1995: 137). In other words, Upper Palaeolithic populations were highly mobile (much more so than the Middle Palaeolithic populations), and as a consequence their short-term occupation of sites significantly reduced the chance that a burial would have occurred at any given site.

6.2.08 Decoration

Decoration in the Levantine Upper Palaeolithic is very rare. Gilead (1995) describes the sole incised object that actually resembles an animal. All other incised objects consist of uninterpretable (usually parallel) lines. Other than incised objects there are bone and tooth "pendants" and shells that are frequently inferred to have been used as beads. The most visible evidence of decoration in the Upper

Palaeolithic of the Near East is ochre. Ochre residue is found on many grinding objects, but it may have been used functionally (for example in the processing of hides) as often as for decoration.

6.2.09 Groundstone

Ground stone implements are not abundant, but they do represent an important aspect of the technology of the period and appear to be strongly correlated with the processing of ochre. Some of the earliest groundstone artefacts were recovered from the earliest Upper Palaeolithic layer in Qafzeh Cave (Ronen and Vandermeersch, 1972) and consist of a quern-like flat mortar and a handstone of basalt (Gilead, 1995: 134). The mortar from Qafzeh and a cobble from El-Khiam (Perrot, 1951) are both examples of the high frequency of Upper Palaeolithic groundstone objects that have ochre stains.

6.2.10 Ochre

Ochre is another aspect of the Upper Palaeolithic that separates it from the Middle Palaeolithic. According to Gilead ochre is rare in Middle Palaeolithic contexts, and he cites Wreschner's 1980 study in which only two Middle Palaeolithic sites are attributed with Ochre – Qafzeh and Geula (Gilead, 1995: 135). Even then the association of ochre with human activities in the Middle Palaeolithic is not clear (Gilead, 1995: 135). On the other hand, ochre is a relatively prominent aspect of the Upper Palaeolithic, but the function of ochre is still unclear (Gilead, 1995). The use of ochre in burials and cave paintings in the Upper Palaeolithic of Europe is well documented, but few burials and no cave paints have been found in the Near East (Gilead, 1995). The possibilities for symbolic, spiritual, and cognitive importance of ochre are obvious, but Keeley (1980) reminds us that ochre has mundane uses (such as the processing of hides) that can not be ruled out (Gilead, 1995).

6.2.11 Settlement Patterns

Settlement patterns in the Upper Palaeolithic are distinct from those of the Middle Palaeolithic. For Example, Gilead presents data that demonstrates that there are fewer sites in the Mediterranean zone for the Upper Palaeolithic than for the Middle Palaeolithic. Gilead draws on Ronen's (1975) review of the sites in which it is stated that 18 caves were occupied in the area north of Jerusalem in the Middle Palaeolithic but only 7 caves were occupied during the Upper Palaeolithic (Gilead, 1995). In addition, Olami (1984) states that in the Mount Carmel area there are only five Upper Palaeolithic sites (all in caves), but there are 72 Middle Palaeolithic sites, of which 12 are in caves (Gilead, 1995). Gilead suggests that this difference in the number of sites 'is not merely a problem of archaeological visibility', and that there is an unexplained shift from the core areas to the marginal areas during the Upper Palaeolithic (Gilead, 1995: 132).

Coinman addresses the issue of expanded occupation in the arid zones during the Upper Palaeolithic from a different perspective. The early research produced a view of the Upper Palaeolithic that was based on data from the Mediterranean zone. Coinman suggests that this perspective is not adequate for interpreting the expanded data set produced by recent research that includes a significant focus on the arid zones. The recent research has documented an extensive use of a wide variety of environmental zones, and only a few of these are comparable to the Mediterranean zones that contained the sites used to formulate Neuville's classical sequence (Coinman, 1998: 55). The Mediterranean zone has been occupied continuously for tens of thousands of years, which makes it probable that many of the open-air sites have either been destroyed or are deeply buried (Olszewski and Coinman, 1998). On the other hand, the arid zones have not been continuously occupied and are often characterised by deflation, which renders the open-air sites more visible.

Another distinction between the Mediterranean zone and the arid zones is that research in the Mediterranean zone has traditionally focused on caves and rockshelters, which have been characterised as basecamps. The intensive and extensive survey of the arid zones has demonstrated that caves and rockshelters are only occasionally the setting for sites, and the majority of sites are open-air (Olszewski and Coinman, 1998: 180). The data from the arid zones provides a much more complete perspective of the range of sites than the traditional Mediterranean research did (Olszewski and Coinman, 1998: 180).

Settlement patterns are inferred from a number of theoretical perspectives. One perspective is that the "function" of a site can be inferred from the components of technology recovered in the archaeological record of that site, with special purpose technology being evident at 'special purpose' sites and general technological elements being evident at base camps where a broad range of activities take place over a relatively long period of time. In his discussion of the Ahmarian industrial tradition found in the Wadi Abu Noshra, Phillips suggests that locally contemporary sites, which display variations in attributes that can be interpreted as functional differences, represents evidence for a 'logistically mobile' settlement pattern. In his comparison of Abu Noshra I and II Phillips states that their tools are distinctly different, and that this indicates that these two sites could represent integral parts of a "logistically mobile" group (Phillips, 1990: 183).

Attempts at reconstructing a logistical settlement pattern in the Mediterranean zone are presented by Olszewski and Coinman. The difficulty with these reconstructions in the Mediterranean zone is the scarcity of sites that might have functioned as logistical task camps for the cave or rockshelter "basecamps" (Olszewski and Coinman, 1998: 178). They suggest that the paucity of logistical sites may be due to either obliteration by subsequent occupation or masking by subsequent deposition (Olszewski and Coinman, 1998: 178).

The cave sites of the Mediterranean zone are often presented as base camp occupations, but the evidence for establishing this perspective is not complete. If Olszewski and Coinman have presented an accurate rationalisation for the missing logistical sites then the debate about the 'archaeological visibility' of Upper Palaeolithic sites is not yet resolved, and Gilead's assessment is questionable. For example, if Upper Palaeolithic logistical sites can be obliterated or deeply buried, then base camps, if some of them were moved out of caves and into open-air contexts, could also be obliterated or deeply buried. In which case the Mediterranean zone during the Upper Palaeolithic could have been as intensively and extensively utilised as it was in the Middle Palaeolithic.

Another aspect of settlement pattern that distinguishes the Upper Palaeolithic populations from the Middle Palaeolithic populations is mobility, which is linked to group size. Upper Palaeolithic populations are often characterised as 'small' and 'highly mobile' (Lieberman, 1993: 604; Gilead, 1995: 128). Gilead cites 'faunal assemblages' and 'small site size' as indicators that suggest small group size and high mobility (Gilead, 1995: 128). He also cites the relative paucity of hearths and ash lenses along with more ephemeral use of caves (Gilead, 1995: 132). For example, the Upper Palaeolithic deposits in Hayonim Cave occupy only a small basin within the Mousterian deposits, and a similar condition is found in Kebara Cave (Gilead, 1995: 132). Gilead explains these differences by invoking a change in subsistence strategy that emphasised a view that Middle Palaeolithic strategies focused on low residential mobility and high mobility between a residential site and a number of logistical sites. The Upper Palaeolithic is characterised by a change to high residential mobility where camps are moved frequently and fewer logistical sites are utilised to extract resources from the surrounding environment. The lithic assemblages seem to support this view. The Mousterian sites display a relatively high intersite variability that is interpreted to indicate the existence of general-purpose basecamps and special-purpose support camps. In contrast, the Upper Palaeolithic lithic assemblages seem to display a relatively low intersite variability that is more commensurate with a "circulating" residential pattern, which is associated with a highly mobile residential strategy (Gilead, 1995: 133). The general view presented by Gilead is apparently representative of a number of archaeologists (see Marks and Freidel 1977, Coinman, Clark, and Lindly 1986, Bar-Yosef and Belfer-Cohen 1989; Lieberman, 1993: 604).

Lieberman's (1993) analysis of tooth cementum seems to support the view that Upper Palaeolithic populations were highly mobile groups. Lieberman explains that tooth cementum accumulates throughout the life of an ungulate, and that the composition of the cementum changes seasonally. This allows researchers to count the layers of cementum to determine the age of the animal at the time of its death and the season of its death. This data has been used to demonstrate that many Middle Palaeolithic sites contain multi-seasonal kills, and that most, if not all, Upper Palaeolithic sites contain single-season kills (Lieberman, 1993; Lieberman and Shea, 1994). This is best displayed at Kebara Cave where the Mousterian levels display a multi-seasonal signature, and the subsequent Upper Palaeolithic levels display a single-season signature (Lieberman and Shea, 1994). This evidence is used to infer that the Upper Palaeolithic populations were occupying sites in a seasonal round (or circulating residential pattern), and that this is distinct from the Middle Palaeolithic populations, which tended to employ a radiating or logistically mobile residential pattern.

Some researchers argue that the settlement patterns in the Levant are more varied than the simple dichotomy between Middle Palaeolithic and Upper Palaeolithic settlement patterns seems to indicate. For example, Olszewski and Coinman suggest that mobility and settlement pattern is the result of a 'dynamic intra-year mix of collecting and foraging systems' (Olszewski and Coinman, 1998). From this perspective hunter-gatherers in the Levant may have employed a complex strategic mixture of circulating, radiating, aggregation, and transhumance behaviour to map onto the shifting availability of resources from season to season, region to region, and year to year (Olszewski and Coinman, 1998; Lieberman, 1993).

6.2.12 Intra-Site Spatial Organisation

The intra-site spatial organisation of Upper Palaeolithic sites is difficult to reconstruct due to the ephemeral nature of the sites. The intra-site spatial organisation of Upper Palaeolithic sites is poorly understood, but the most prominent feature is hearths, which are some times inferred from ash accumulations (Goring-Morris, 1988; Gilead, 1995). Hearths, themselves, display evidence that they are becoming more elaborate and possibly more formalised. Several sites have hearths in a linear arrangement and some hearths have wadi pebbles around or incorporated into part of the hearth (Gilead, 1995: 132). The hearth is the most visible feature of Upper Palaeolithic sites, and activity areas appear to be arranged around the hearth.

6.2.13 Subsistence

Redman (1978) states that the subsistence strategies of the Upper Palaeolithic represent a 'fundamental change' that is evident in the 'reduction in the variety of foods that were utilised'. This view is based on faunal evidence only. Archaeological methodology and poor preservation at most Upper Palaeolithic sites precluded the inclusion of floral data at the time of Redman's review. Redman's interpretation of this change in subsistence strategies is stated as follows:

> "The change is probably indicative of greater planning, communication, and organisation in carrying out the hunt and of a difference in attitudes toward food and the environment." (Redman, 1978)

There is a tendency to attribute any change in behaviour in the Upper Palaeolithic to the increased capabilities of the populations due to the fact that all archaic forms of Homo sapiens have apparently disappeared at this time. It is interesting to note that 'specialisation' in hunting is interpreted here as an indication of 'advanced capabilities', and that later the return to a more 'broad-spectrum' subsistence strategy will also be interpreted as an indication of advanced capabilities (see Henry, 1989).

The early view, presented by Redman (1978), of a specialised subsistence economy has not been supported by more recent research (Chase, 1987). This is partly due to a more comprehensive reconstruction of the available resources. The

Levant is unusually heterogeneous in flora and fauna because it is the only land corridor between Africa and Eurasia, and because it consists of five major geomorphological zones (Lieberman, 1993). A third source of variation is the Mediterranean climate, which results in distinct seasonal difference in resource distribution (Lieberman, 1993). This variety in resources does not seem to correspond to a view of a specialised subsistence economy.

Palaeobotanical and human remains are rare in Upper Palaeolithic contexts (Arensburg 1977, Gilead 1991 [from Lieberman, 1993: 604]). Reconstructing diets and subsistence strategies is extremely difficult, and without access to direct evidence diets and subsistence are reconstructed based on inference from secondary sources such as ethnographic analogy and data on the resources that were generally available. For example, Gilead states that the vegetal component of human diet during the Upper Palaeolithic is practically unknown, but possible food sources can be inferred from sources such as charcoal analysis. In this way the existence of oak, tamarix, olive and pistachio can be established at several sites, but the link between the existence of these resources and their utilisation for more than just fuel are highly conjectural (Gilead, 1995: 126).

Lieberman's perspective of the Upper Palaeolithic is that the faunal evidence suggests a continuing utilisation of resources that were exploited in the Middle Palaeolithic (Lieberman, 1993: 604). It would seem that Gilead's perspective of subsistence would support such a conclusion. For Example, he states:

> "The Upper Palaeolithic faunal assemblages are similar in nature to the other Middle Palaeolithic (excluding hippopotamus and elephants) and Epipalaeolithic assemblages. They suggest a subsistence economy of extensive gathering of the available resources scattered over the landscape, rather than any specialised foraging." (Gilead, 1995: 128)

The most important meat sources in the Upper Palaeolithic were the bovids, cervids, and equids, but the role of smaller mammals, reptiles, fish and birds is not clear (Gilead, 1995: 127). For example, the use of ostrich eggs seems to be common at the sites in the marginal areas (Gilead, 1995: 128). Gilead concludes that there is no apparent fundamental change in subsistence from the Middle to the Upper Palaeolithic, and that the available evidence does not support the view that the smaller resources were added to the diet only after 20 kya (Gilead, 1995).

6.2.14 Conclusion: Upper Palaeolithic Summary

There is apparently a lack of consistent perspective to research in the Near East. At every level and within every topic researchers seem to be working at cross-purposes whenever they discuss or summarise archaeological research and data. For example, there exist a large number of perspectives of lithic assemblages that range from specialised typological characterisations to information analysis of technological processes. These problems are further compounded by the large number of conclusions as to the cultural implications of such analyses.

In general, the archaeological record for the Upper Palaeolithic is very ephemeral, and possibly due to this fact it appears to be less developed than other periods.

6.3 THE EPIPALAEOLITHIC OF THE NEAR EAST

The terminal palaeolithic period of the Near East is often referred to as the Epipalaeolithic. In the 1970's it was loosely defined as the microlithic industries that are found situated temporally between the Levantine Aurignacian and the Pre-Pottery Neolithic (Solecki and Solecki, 1983: 123; Gilead, 1990: 178). Currently the term 'Epipalaeolithic' does not represent a universally defined and accepted entity as is evident in the following statement:

> "...the period from approximately 20,000BP to 12,800/12,500 BP. This segment of the Late Pleistocene bridges the gap between the Upper Palaeolithic and the Natufian. A number of terminological frameworks have been applied to this time segment, with the label Epipalaeolithic variously applied to all, part, or none of this time period and the subsequent Natufian (Bar-Yosef and Vogel 1987: 220; Byrd 1994a; Gilead 1984; 1991: 133; Goring-Morris 1987; Henry 1989)." (Byrd, 1998: 64)

Also, the term 'Epipalaeolithic' is rarely used when discussing comparable material in the Zagros Mountains, which may be due to the lack of research conducted there since the 1970's.

A discontinuity is typically perceived between earlier Epipalaeolithic phenomena and the Natufian (Neeley *et al.*, 1998: 295, Gilead, 1990: 180; Solecki and Solecki, 1983: 123). The exact nature of this distinction is not well defined, but it often revolves around changing subsistence and settlement strategies (Neeley *et al.*, 1998: 295; Gilead, 1990: 180). This is evident in the fact that the Epipalaeolithic has often been characterised as being important because it is the predecessor to domestication and sedentary village life (Neeley *et al.*, 1998: 295; Byrd, 1998: 64; Goring-Morris, 1995: 142). Epipalaeolithic sites can contain any or none of a suite of characters that represent an impression of a distinct difference when compared to Upper Palaeolithic sites. Increasing quantities of groundstone, decorative objects and constructed rock features are some of the more tangible aspects of Epipalaeolithic sites. The possible presence of a midden at Tor al-Tareeq (Neeley *et al.*, 1998: 313), brush huts at Ohalo II (Nadel and Werker, 1998), and increasing thickness of occupational layers (Byrd, 1990: 259) are examples of the less tangible and more difficult to quantify aspects of the Epipalaeolithic impression.

The Natufian is often included in the Epipalaeolithic sequence, but it will be dealt with separately in this review.

6.3.01 Chronology

The chronological sequences of the Near East are difficult to establish with any degree of certainty. One problem is that most current research relies on radiocarbon dating to establish sequences, but due to differential research intensity the radiocarbon data from adjacent regions in the Near East are not comparable. For example, the lack of research in the Zagros Mountains since the 1970's has resulted in a very low number of radiocarbon dates for these sites. Comparing chronological sequences from the Zagros Mountains and the Levant often relies on determining typological similarities of lithic assemblages (which is problematic due to other methodological inconsistencies that are discussed later). Another problem is that not all sites produce radiocarbon dates. For example, in the Levant there are many sites with good radiocarbon dates, but not all of the sites that contain crucial data have produced radiocarbon dates. This produces a situation where crucial sites must be fitted into a chronological sequence based on relative dating techniques. A third problem is that radiocarbon dating has proven to be a less obvious measure of time than was once hoped. For example, Goring-Morris (1995) points out that the radiocarbon dates at 20,000 years BP are as much as 3500 years younger than the true ages (based on Bard *et al.*, 1990). Finally, sequences are often discussed from a number of perspectives (i.e. radiocarbon years, calibrated radiocarbon years, calendar years,...).

In the Levant the Epipalaeolithic is broadly defined as the period from 20,000-10,000 BP (Goring-Morris, 1995). Byrd (1990) has divided this period into an Early and Late phase. The Early phase lasting from 20,000-15,500 BP and the Late phase lasting from 15,500-10,500 BP. Garrard (1998) divided the Epipalaeolithic into an Early, Middle, and Late phase. The early and middle phases encompass the two Kebaran complexes and the late phase coincides with the Natufian. MacDonald *et al.* (1998) define the Epipalaeolithic as ca. 14,000-8,000 B.C. Neeley *et al.* (1998) describe the Epipalaeolithic as the interval from 20,000 to 10,000 b. p. The Geometric Kebaran is generally accepted to be in the range of 15,00-12,000 BP (Kaufman, 1989; Henry, 1983; Bar-Yosef, 1981) and the Kebaran precedes this period and Natufian succeeds it.

6.3.02 Context

The Epipalaeolithic is a term that is primarily used for Levantine sites, and the majority of sites discussed here are from the Southern Levant. Bar-Yosef states that the boundary that divides the Levant into the north and the south is an east-west line that runs through the Galilee, the Golan Heights and north of the Gebel Druz into the Syro-Arabian Desert (Bar-Yosef, 1998: 162).

6.3.03 Methodology

One of the primary considerations for understanding the archaeology of the Near East is the geographic distribution and differential intensity of research. It has already been mentioned that very little research has been conducted in the Zagros Mountains since the 1970's, but even in the Levantine research has not been uniform. For example, Bar-Yosef (1998) states that the areas west of the Jordan River received the bulk of attention in the Nineteenth and the first half of the twentieth centuries. Bar-Yosef (1998) also points out that due to geo-political reasons researchers on opposite sides of the Jordan River were isolated from each other. The third point that Bar-Yosef (1998) makes is that the archaeology east of the Jordan was led by a different combination of scholars, some of whom preferred to base their research on newly developing technologies and perspectives such as radiocarbon dating. All of this leads to a situation where sites and assemblages on the east side of the Jordan River are not easily compared to or combined with data from the west side of the Jordan.

Variation and uniformity of lithic assemblages are used to infer a wide range of site attributes. For example, uniformity of specific aspects of a number of sites has been used to infer social group identity in the landscape (Goring-Morris, 1995: 143). The presence of a limited number of tool forms on a site has been used to infer small group size and short occupation length for that site (Goring-Morris, 1995: 143). Also, major typological classes of tools are assumed to reflect broad functional categories that can be used to infer the range of tasks performed on a specific site (Goring-Morris, 1995: 144).

6.3.04 Chipped Stone Production

One aspect of Levantine Epipalaeolithic research that distinguishes it from earlier eras is the proliferation of names used to classify assemblages (Neeley *et al.*, 1998: 297). The production of microliths is the most prominent factor that distinguishes Epipalaeolithic assemblages from earlier assemblages, and it is the frequency of types of microliths that is used to separate Epipalaeolithic assemblages into categories. These categories are often presented as being analogous to ethnic or social identities (Bar-Yosef, 1991; Kaufman, 1995 [from Neeley *et al.*, 1998: 296]). In contrast, some researchers suggest that these variations in microlith frequencies are more likely to be correlated with aspects of the forager's life such as raw material quality and availability, forager mobility and group size, or site function (Bamforth 1986, 1991; Kuhn 1991, 1994 [from Neeley *et al.*, 1998: 297]). Garrard (1998: 144) suggests that during the Middle and Late Epipalaeolithic there was an increase in the similarity of industries of the Central and Southern Levant.

Other aspects of technology become significant components of material culture in the Epipalaeolithic. For example, Byrd (1990) lists basalt grinding stones, bone points, pieces of ochre, and dentalium as items that become common in the Epipalaeolithic. Also, the presence of quantities of burnt stone in some Epipalaeolithic sites has been interpreted by some researchers as evidence of a technological innovation, possibly associated with cooking (Goring-Morris, 1990: 242).

In the Southern Levant the microlithic component of the Epipalaeolithic assemblages has been used to identify social territories (Garrard, 1998: 143). This methodology is not without criticism (e.g. Neeley and Barton, 1994). Neeley *et al.* (1998) suggest that the variation can be explained by a range of situational variables (e.g. raw material size and availability, forager mobility, local group size, and site function), which affect all mobile foragers (Neeley *et al.*, 1998: 297). On the other hand, radiocarbon dates do support the view that microlithic forms have spatial and temporal significance (Garrard, 1998: 143 [see also Bar-Yosef, 1990; Fellner, 1995: Goring-Morris, 1995; Henry, 1995; and Byrd, 1998]). Temporal and regional classifications are based primarily upon the frequency and type of geometric and non-geometric microliths (Neeley *et al.*, 1998), and these complexes were first defined in the coastal regions of the western Levant. In the southern Levant (and west of the Jordan Valley) Byrd (1998: 64) identifies three cultural complexes that predate the Natufian. These are the Kebaran, the Geometric Kebaran, and the Mushabian (see also Bar-Yosef 1981, 1991; Bar-Yosef and Belfer-Cohen 1989, 1992; Henry 1989; Valla 1988). Byrd recognises that others have been proposed, but these three are the ones that have been reasonably well established in the literature (Byrd, 1998: 64).

The Kebaran is the first of the broad categories of assemblages. The Kebaran dates from 19,000 to 14,500 b. p. (Neeley *et al.*, 1998: 296), and is succeeded by the Geometric Kebaran. The Kebaran is defined by a high frequency of backed non-geometric microliths and the absence of the microburin technique (Neeley *et al.*, 1998: 296; Lieberman, 1993: 604; Gilead, 1990:178; Henry, 1983: 124). Goring-Morris notes that Upper Palaeolithic and Early Epipalaeolithic occupations cannot always be distinguished based on lithic assemblages alone (Goring-Morris, 1987: 79).

The Geometric Kebaran is generally accepted to have evolved from the Kebaran (Henry, 1989: 175). The Geometric Kebaran is distinguished from the Kebaran by its high percentage of geometric microliths, typically trapeze-rectangles (Neeley *et al.*, 1998: 296; Lieberman, 1993: 604; Bar-Yosef and Belfer-Cohen 1989; Bar-Yosef 1975, 1981). Goring-Morris (1987: 142) recognises the 'Hamran' (from the southern Transjordan) as a local variation of the Geometric Kebaran.

The Mushabian is principally found in the Sinai and overlaps spatially and temporally with the Geometric Kebaran (Neeley *et al.*, 1998: 296). The Mushabian is distinguished by the use of the microburin technique to manufacture non-geometric microliths (Neeley *et al.*, 1998: 296). Unlike the Geometric Kebaran, the backed bladelets of the Mushabian are dominated by arched forms (Henry, 1989: 93).

In addition to the Kebaran, Geometric Kebaran, and the Mushabian, some authors have separated some of the assemblages into other complexes. Two of the earliest of these complexes are the Nebekian and the Qalkan. The Nebekian has been found in the steppe to the south and east of the Jordanian and Syrian highlands, and it is also known from the northern Negev (Garrard, 1998: 144). Examples of the Nebekian are found in the Azraq Basin, and they are dated to 19.8-18.4 kya. The Azraq examples of the Nebekian are characterised by narrow, finely made, curved, pointed, arched-backed pieces (Garrard, 1998: 143).

The Qalkan has also been found in the steppe to the south and east of the Jordanian and Syrian highlands and is known from the Negev (Garrard, 1998: 144). Examples of the Qalkan have been found in the Azraq Basin, and they are characterised by la Mouillah points and double truncated backed bladelets made on large robust blanks (Garrard, 1998: 143). The Azraq Basin examples of the Qalkan date to 18.9-18.4 kya (Garrard, 1998).

A third complex that has been proposed is the Nizzanan (Goring-Morris, 1995). The Nizzanan is found at scattered localities in both areas of the southern and central Levant (Garrard, 1998). An example of the Nizzanan has been recovered from the Azraq Basin, and it is dated to 16.7-15.5 kya. The Nizzanan from the Azraq Basin is characterised by small asymmetric triangles, symmetric triangles, and microgravette points (Garrard, 1998).

Other assemblages have been recovered that do not seem to fit into any of the proposed complexes (Garrard, 1998). For example, in the Azraq Basin an assemblage dating to 13.5-13.0 kya is described as a "non-microlithic blade-based industry" that contains "tanged knives" that are unique in the Near East (Garrard, 1998). Garrard states that this unique knife resembles tanged points from contemporary sites in northwest Europe, but microwear studies have demonstrated that the tanged knives were hafted and used for cutting and not as a projectile point (Garrard, 1998).

6.3.05 Architecture

Architectural remains are extremely rare in the Epipalaeolithic before the stone built structures of the Natufian (Nadel and Werker, 1999 [see also Bar-Yosef and Belfer-Cohen, 1989 and 1992; Henry 1989; Garrard *et al.*, 1994; Goring-Morris, 1995; and Marks, 1976 and 1977]). The site of Ohalo II provides a rare example of three huts that have been recovered due to the high degree of preservation at this waterlogged location. Other examples of Epipalaeolithic structures can be found at Jilat 6 (Garrard *et al.*, 1994) and Ein Gev 1 (Arensburg and Bar-Yosef, 1973; Bar-Yosef, 1978), but these are only partially preserved floors (Nadel and Werker, 1999).

Some sites contain stone features and alignments that make them more visible, but not necessarily more comprehensible. At Tor al-Tareeq a rock alignment cannot be firmly associated with the early Epipalaeolithic levels, nor can it be conclusively identified as part of a living structure (Neeley *et al.*, 1998). Two stone structures have been identified at the Geometric Kebaran site of Neve David (Henry, 1989). One of the stone structures is a slightly arched wall, and the other structure is an oval with a diameter of about 1 meter. About all that can be said about these two structures is that they were constructed of undressed limestone slabs, and the oval structure seems to have contained a hearth (Henry, 1989).

6.3.06 Beads

Beads made from bone, teeth, shell, and stone become quite common in the Epipalaeolithic, and the fact that marine shell beads were found at many of the sites in the Azraq Basin establishes that long-distance transportation of resources is a part of Epipalaeolithic life (Garrard, 1998 [see also Neeley *et al.*, 1998]). At Tor al-Tareeq marine shells originated from both the Mediterranean Sea and the Red Sea (Neeley *et al.*, 1998). The distance to the Red Sea is 155 km and the distance tot the Mediterranean Sea is 135 km, but access to the Mediterranean Sea is more difficult due to the Rift Valley and the Lisan Lake (Neeley *et al.*, 1998). At Ein Aqev three marine shells were covered with Ochre (Marks, 1976).

6.3.07 Bone Tools

Other aspects of technology become significant components of material culture in the Epipalaeolithic. For example, Byrd (1990) lists basalt grinding stones, bone points, pieces of ochre, and dentalium as items that become common in the Epipalaeolithic. Bone preservation at many Epipalaeolithic sites is poor, especially in the Negev and Sinai (Goring-Morris, 1987: 140 p.1). Ohalo II represents an example of a very well preserved site. A high degree of preservation is indicated by several aspects of the site including the presence of tens of thousands of charred seeds and thousands of animal bones (Nadel, 2001). The bone tools at Ohalo II numbered in the dozens (Nadel, Carmi, and Segal, 1995). Among the types of worked bone were several examples of incised bone fragments, and one of these was contained in the fill of a burial on the site (Nadel, 1994).

6.3.08 Groundstone

The presence of groundstone implements in Kebaran sites is significant relative to the Upper Palaeolithic sites but relatively rare compared to later Epipalaeolithic occurrences (Byrd, 1998). Compared to the typical handstone of the Kebaran the groundstone from the Geometric Kebaran site of Neve David shows extensive elaboration. The groundstone implements at Neve David are notable for both their quantity and their range of types (Kaufman, 1989). The tools are made of both basalt and limestone, and they include deep mortars, shallow bowls, flat grinding slabs, and handstones (Kaufman, 1989). A similar array of groundstone was found at Hefsibah (Henry, 1989: 158), and no less than ten Geometric Kebaran sites containing groundstone are discussed by Goring- Morris (1987). Byrd (1998) reinforces the view that groundstone artefacts in the Epipalaeolithic are generally uncommon, and they are typically small and portable. On the other hand, the groundstone artefacts of the Epipalaeolithic (even before the Natufian) are more abundant and significantly more sophisticated than they were in the Upper Palaeolithic (Bar-Yosef, 1980). For example, some of the groundstone at Tor al-Tareeq display multiple use surfaces (Neeley *et al.*, 1998).

6.3.09 Hearths

Hearths in the Epipalaeolithic display some aspects of an increasing sophistication of behaviour. First, hearths are more frequently associated with other features such as the huts and pits at Ohalo II (Nadel and Werker, 1999), the architectural feature at Tor al-Tareeq (Neeley *et al.*, 1998), and the architectural feature at Neve David (Kaufman, 1989). Second, some hearths are associated with burned stone (such as at Tor al-Tareeq), which may indicate a more sophisticated cooking technique. Third, the construction of hearths is more elaborate. For example, Ein Aqev contained a stone lined hearth (Goring-Morris, 1990), and Kharaneh IV contained a rectangular hearth (Muheisen, 1988).

6.3.10 Ochre

Ochre is present at a number of Epipalaeolithic sites, but its use is largely undetermined. In the Azraq Basin at the site of WJ6 two ochre-pigmented surfaces were discovered, and at Ein Aqev three shells were covered with ochre (Marks, 1976).

6.3.11 Settlement Patterns

Epipalaeolithic sites show a trend of increased site size, site utilisation, and site distribution. There is even a trend within the Epipalaeolithic towards more visible sites that is probably due to increasing intensity of occupation (which could include any or all of the following: larger groups, increasing frequency of reoccupation of sites, longer occupation of sites). One clear example of increased intensity of occupation is seen in the low-level introduction of facilities such as bedrock mortars as seen in the Wadi el-Hassa (Neeley *et al.*, 1998: 309). Nishiaki makes similar observations about the Syrian Epipalaeolithic sites:

> "In Syria, Epipalaeolithic sites show a marked increase over previous ones, and their distribution also extends over a larger region including the northern steppe." (Nishiaki, 1998: 201)

This is probably connected to an increasing tendency to reoccupy sites. There are a number of good examples of sites that are comprised of several sequences of re-occupation. This was very unusual in previous periods except within cave and rockshelter contexts. Tor al-Tareeq is an example of a relatively large site (812 sq. m) that has been characterised by Neeley *et al.* (1998) as a series of camps along the edge of Lake Hassa. Based on typological differences Neeley *et al.* (1998) demonstrate that two major culture-stratigraphic phases can be differentiated - an earlier non-geometric phase and a later geometric phase. This demonstrates that Tor al-Tareeq is a site that has been reoccupied a number of times over several millennia. Tor al-Tareeq also displays an increase in intensity of occupations, which is evident in that the geometric occupations are associated with a number of groundstone artefacts, four of which are bedrock mortars (Neeley *et al.*, 1998). Byrd (1990) also cites evidence that some of the Jilat and Uwaynid sites were repeatedly reoccupied.

Ohalo II is another example of a site that has been characterised as having been repeatedly reoccupied and occupied for longer periods of time. Evidence that establishes the multi-occupational nature of Ohalo II is that the hut walls display evidence of rebuilding episodes and the floor of the hut displays distinct stratified occupational surfaces (Nadel and Werker, 1999; Nadel *et al.*, 1995; Nadel, 1994). Another aspect of Ohalo II that suggests an increase in the amount of time spent on the site (due to both increasing lengths of stay and increasing reoccupation of sites) is the presence of a burial. Burials in the Kebaran and Geometric Kebaran are relatively rare with only about a half dozen burials documented.

The Kebaran sites display a number of common features. First, the geographic distribution of Kebaran sites is strongly correlated with the core Mediterranean zone of the Levant (Henry, 1983: 125; Bar-Yosef, 1981: 395). Second, a significant number of sites display evidence of repeated episodes of occupations containing comparable lithic assemblages that are arranged in discernible occupation levels that may span several millennia (Goring-Morris, 1987: 58). Third, Kebaran site size is slightly larger than that typically found in the Upper Palaeolithic, and it ranges from 15-25 sq. m. to 100-150 sq. m. (Bar-Yosef, 1981: 395). Forth, most Kebaran sites are found in the lowlands and in close proximity to wadis (Bar-Yosef, 1981: 395). Site distribution for the Kebaran may be biased by 'archaeological visibility', but some researchers argue (based on palaeo-environmental reconstructions) that the highlands were too heavily forested and the Negev and Sinai were too dry for discernible occupation during the Kebaran. Due to small site size and relatively low investment in most sites the Kebaran is typically characterised as representing high residential mobility that is similar to the Upper Palaeolithic (Neeley *et al.*, 1998: 296)

Geometric Kebaran sites tend to be slightly larger than Kebaran sites, and they typically range from 15 sq. m. to 400 sq. m. (Henry, 1983: 131; Bar-Yosef, 1981: 398). Sites in the Negev and Sinai are relatively small. They rarely exceed 50 sq. m., and never exceed 100 sq. m. (Goring-Morris, 1987: 140). Geometric Kebaran sites are less ephemeral than Upper Palaeolithic or Kebaran sites, and 'living floors' are discernible more often (e.g. Umm el-Tlel and Nadaouiyeh [Nishiaki, 1998: 201]). The Geometric Kebaran displays evidence of expansion (Henry, 1983). The exploitation of highland environments is evident in the Geometric Kebaran, and Henry cites Neba'a el Maghara in the Lebanese Mountains (Hours, 1976) and En el Bieda on the Golan Plateau (Ben-Ami, 1975) as examples of upland habitation (Henry, 1983).

Betts states that settlement patterns in the arid regions are closely related to the distribution of water and vegetation (Betts, 1998). It is apparent that a number of settlement strategies were employed in the Epipalaeolithic (Olszewski and Coinman, 1998). For example, in Southern Jordan Henry (1994 and 1995) has presented data that supports a mixture of adaptive settlement strategies (Olszewski and Coinman, 1998). Some of the Epipalaeolithic populations in the Ras en-Naqb region occupied long-term basecamps (that were typically located in low-land rockshelters) during the winter months. In contrast, during the summer months these people apparently employed a highly mobile strategy of frequent moves around ephemeral up-land open-air sites (Olszewski and Coinman, 1998). In the Azraq Basin the Epipalaeolithic sites seem to be characteristic of a relatively mobile settlement strategy, but two sites (Jilat 6 and Kharaneh IV) may have been "seasonal Aggregation" sites (Garrard and Byrd, 1992: 60; Garrard *et al.*, 1994: 184 [from Olszewski and Coinman, 1998]; Garrard, 1998). Some Mushabian sites have also been suggested to represent small-scale seasonal aggregation (Neeley *et al.*, 1998). Henry (1989: 151) also suggests that there is an increase in artefact variability due in part to this increased geographic occupation and the attendant adaptive responses.

6.3.12 Intra-Site Spatial Organisation

In the Epipalaeolithic the intra-site spatial organisation is becoming an important aspect of archaeological research (Goring-Morris, 1990). This is partly based on ethnographic research (e.g. Yellen, 1977; Binford, 1978, 1983; O'Connell, 1987; Gould and Yellen, 1987; and Schiffer, 1987), which demonstrated that populations tend to make spatial arrangements in a recognisable and consistent pattern (Goring-Morris, 1990). Goring-Morris suggests that intra-site spatial organisation can potentially provide insight into group sizes, social composition, and technologies (Goring-Morris, 1990). In the Levant a good example of the application of this perspective to fieldwork is provided by the Emergency Archaeological Survey of the Negev. One of the primary goals of the prehistory unit has been the complete excavation of sites to systematically investigate the internal patterning of occupations (Goring-Morris, 1990).

From his review of the Epipalaeolithic sites in the Negev and the Sinai Goring-Morris (1990) concludes that hearths and architectural features are the principle determinants of the intra-site spatial organisation of activities within sites.

Hearths also provide some information as to group size. For example, in the Negev no Geometric Kebaran site contains more than a single "household" hearth, which could indicate that these sites are typically small intimate kin groups based on a single household (Goring-Morris, 1990).

Ohalo II is an exceptionally well-preserved site, and it provides good evidence for intra-site spatial organisation. The site contains huts with hearths located outside of the huts, and there is a rock feature, which is also located outside of the huts and away from the hearths (Nadel and Werker, 1999: 755). Distribution of debris within the site indicates that similar tasks were performed at locations within the huts and outside around the hearths (Nadel and Werker, 1999: 755). The logical implication is that the site is not organised with specialised work areas.

Lagama North VIII provides one of the best examples of intra-site spatial organisation within a Geometric Kebaran site from the Negev and Sinai (Goring-Morris, 1987: 141). A probable shelter is indicated on the site by the presence of an open cleared area delimited by a hearth and primary refuse to the north and the south of the hearth (Goring-Morris, 1987: 141). Unlike the Ohalo II occupation, the Lagama occupation seems to indicate that task areas were not located within the shelter. Much more data on intra-site spatial organisation is needed before we can begin to discuss the significance of the differences between the intra-site spatial organisations of these two sites.

6.3.13 Subsistence

Reconstructing subsistence in the Epipalaeolithic is no longer restricted to faunal evidence. There now exists limited direct evidence for the floral aspect of subsistence in the Epipalaeolithic (Byrd, 1998), but floral evidence is so limited that the sites where it is found comprise a relatively short list (i.e. Ohalo II (Kislev *et al.* 1992): Tell Abu Hureya (Hillman 1989b); Wadi Hammeh 27 (Colledge, in Potts *et al.* 1985); and Hayonim Cave (Hillman 1989a [from Goring-Morris, 1995]). The reconstruction of much of the subsistence in the Epipalaeolithic is still dependant on secondary evidence. Secondary evidence can be flawed by preconceptions and bias. For example, the deep mortars that are abundant in the Natufian but begin to appear in the Epipalaeolithic have traditionally been interpreted as an indication of cereal grain processing. Based on experimental work, the deep mortars appear to be better suited to the processing of nuts rather than grains (Henry, 1989). There are two main reasons for the lack of floral data. First, the employment of adequate technology and methodology for recovering floral data is relatively new in the Near East. Second, the soils in the Levant are not conducive to the preservation of floral remains (Goring-Morris, 1995).

Some researchers have suggested that the Epipalaeolithic is characterised by shifting patterns of food resource utilisation. For example, in the Hasa region of Jordan basecamps appear to be fewer in number, situated across a broader range of microhabitat locales, and contain increasing numbers of groundstone implements used for the processing of plant food (Olszewski and Coinman, 1998: 192). Also, Ostrich is a common resource in the Negev, and this is a clear indication of the variety of subsistence strategies employed by hunter-gatherers in the Epipalaeolithic (Marks, 1976).

Several sites in Jordan have yielded evidence of seed utilisation, and WJ6, dating to 16 kya, includes steppe grasses, chenopods, and sedge seeds (Colledge and Hillman, 1988 [cited in Garrard, 1998]). Ohalo II is a site where the high degree of preservation allowed the recovery of an impressive array of plant remains. The remains of tens of thousands of seeds and fruits have been identified as belonging to about 100 species (Nadel and Werker, 1999). Sites such as these indicate that the resources that are normally connected with groundstone artefacts were in use long before groundstone becomes a common aspect of the material culture of the Near East.

6.4 THE NATUFIAN

"The Natufians were hunter-gatherers, but they differed from previous hunter-gatherers in the Levant in many significant respects (Belfer-Cohen 1991): some Natufians lived in large complex sites with permanent architecture, and they produced numerous sickle blades, grinding stones, and much of the first art from the region, they also buried their dead in cemeteries, and domesticated the dog." (Lieberman, 1993: 600) The Natufian phenomenon is so striking that it has often been set apart from the earlier hunter-gatherers of the Levant.

6.4.01 Chronology

The temporal resolution of the Natufian is complicated by a number of factors. First, there are a number of ways to designate temporal intervals. For example, Sellars (1998) describes the Natufian as the interval from 12,500 BP to 10,500 BP, but Bar-Yosef places the Natufian in the interval from 10,300 to 8,500 BC (Bar-Yosef, 1983). Second, the use of radiocarbon dating techniques is hampered by the fact that the preservation of charcoal in terra rossa soils is very bad (Bar-Yosef, 1981). Finally, the variation in atmospheric carbon means that there is no simple correlation between radiocarbon dates and calendar dates (as was once thought).

6.4.02 Context

The Natufian was originally thought to be confined to the core Mediterranean zone of the Levant. Now there are sites that are recognised as Natufian in Lebanon, Syria, Jordan, and possibly Egypt. The Natufian remains a fundamentally Levantine phenomenon.

6.4.03 Chipped Stone Production

At one time the presence of lunates in an assemblage was taken as an indication that the assemblage was part of the Natufian complex. More recent work (Bar-Yosef, 1970; Henry, 1973) demonstrated that this view of lunates must be revised (Sellars, 1998). Lunates have now been found in Iran and India, and in the Levant they have been found in Mushabian and Negev Kebaran assemblages (Sellars, 1998).

The Natufian assemblages appear to display a relatively high degree of uniformity. For example, the Jordanian Natufian assemblages generally fall well within the range of variation that was established based on the assemblages from the Mediterranean sites (Sellars, 1998). Much of the perceived uniformity is based on qualitative and metric aspects of blank forms in the Natufian assemblages (Henry, 1977; 1985 [from Sellars, 1998]). In other words, Natufian tool classes display a considerable range of variation, but the blank production is remarkably uniform (Henry, 1989). Henry (1983) interprets this uniformity as being produced by the movement of stone working persons from community to community.

One of the aspects of the Natufian assemblages that distinguish them from earlier occurrences is core utilisation. Natufian flint cores are much more thoroughly exploited, and one hypothetical explanation for this fact is that Natufian populations were less mobile so they had less access to flint resources (Belfer-Cohen, 1991).

According to Henry (1989) the Natufian complex is difficult to characterise because it contains the least specialised tool kits (in that the major tool classes are relatively well balanced, and there are large ranges of variation for each class). Nevertheless, the Natufian complex can be clearly identified (Henry, 1989). First, the backed bladelets of the Natufian are almost all of the arched or straight-backed varieties and rarely contain lamellas scalene or La Mouillah points (Henry, 1989). Second, the geometric component of the Natufian is dominated by lunates (Henry, 1989). Finally, the microburin technique is a habitual part of the Natufian technology (Henry, 1989).

6.4.04 Architecture

The Natufian produces the earliest known examples of substantial architecture in the Near East, and it is characterised by large, well-made structures that seem to be arranged in closely spaced groups, which could be described as villages (Valla, 1995; Redman, 1978). Natufian architecture is the newest distinct behaviour that can be used to distinguish some Natufian sites from earlier occupations (Valla, 1995). The semi-subterranean structures of the Natufian are not an absolute innovation, but they display a number of features that distinguish them from earlier occurrences such as the isolated hut at Ein Gev (Valla, 1995). Natufian structures appear to be more carefully planned, they involve considerably more effort, and they are found in closely spaced groups, which is why they are sometimes referred to as "villages" (Valla, 1995). For example, at Mallaha there are an estimated fifty structures that are large enough to constitute dwellings, and this array of "houses" could represent a community of 200-300 people (Redman, 1978).

The larger structures range from 3-9 meters in diameter, and they display a relatively consistent construction, which is described by Redman (1978). The structures are excavated up to one meter into the underlying sediments and the walls are faced with undressed stones. The shape of the structures tends to be circular, but a few are more oval. Most of these structures contain at least one hearth, and these hearths tend to be centrally located and relatively elaborately constructed (Redman, 1978). The construction of structures such as the ones found at Mallaha required a considerable level of investment of time and effort. Not only were large quantities of stone transported to the site, but also large volumes of dirt were moved (Henry, 1989). Henry states that the arrangement of structures is consistent, but at some sites or period of a site the arrangement is linear and at others it is clustered (Henry, 1989).

Outside of the core Mediterranean area some sites that are sometimes included in the Natufian classification display variations on the construction of structures. For example, at Abu Hureya the structures are cut into the subsoil but the walls are not faced with stone (Henry, 1989). At Mureybet the walls of structures are fashioned from clay and timber instead of stone (Henry, 1989). Finally, a structure at Rosh Zin contains a unique monolithic limestone column that has been interpreted as a ceremonial feature (Henry, 1989: 212).

6.4.05 Beads

Decorative items become common for the first time in the Near East with the advent of the Natufian, and the most common form was beadwork, especially in the form of the marine shell *Dentalium* (Sellars, 1998). The use of *Dentalium* as beads has been established by the evidence for cutting and drilling them (Reese, 1991), and through the recovery of items of body adornment from burials (Sellars, 1998). Beads are made from a number of materials including marine shells, worked bone, teeth, and incised and drilled stone (Belfer-Cohen, 1991). The increase in artistic activities (such as bead making) is interpreted by some researchers as an indication of increasing social interaction and social tension (Belfer-Cohen, 1991).

6.4.06 Bone Tools

The Natufian represents an unprecedented abundance (both in quantity and variety) of worked bone (Belfer-Cohen, 1991). The rich bone assemblages contain both functional and decorative items (Belfer-Cohen, 1991).

Wear analysis of the bone tools has produced microscopic evidence that indicates that many of these tools were used for weaving or hide working (Belfer-Cohen, 1991).

The bone assemblages from the Natufian indicate the advent of a new production technique. Earlier bone industries were produced almost exclusively by scraping and shaving the bone. Many bone artefacts from the Natufian were produced using a grinding technique (this is seen mostly on beads and pendants). This is especially interesting because grinding was a common technique for working bone in the succeeding Neolithic cultures (Belfer-Cohen, 1991).

The abundance of bone tools, which are more time consuming to make than wood tools, is interpreted as an indication of a secure economic base and an increase in time that could be spent in the enrichment of the material culture by Bar-Yosef and Tchernov (1970). On the other hand, Henry (1989) interprets the abundance of bone objects as an increase in the social interaction, such as displays of status.

6.4.07 Burials

More than 400 Natufian burials had been recovered by 1990 (Belfer-Cohen, 1991). The burials seem to be in every possible form and variety (Belfer-Cohen, 1991). One consistent aspect of Natufian burials is the strict separation of burials and living areas (Belfer-Cohen, 1991).

Some researchers interpreted the mortuary patterns as an indication that Natufian society was stratified with either a sub-group ranking system or a community ranking system (Henry, 1989). Wright (1981) inferred inherited status and subgroup differentiation from the Natufian burials based on Binford's (1971) ethnographic survey of mortuary practices. Some researchers have suggested that Natufian burials indicated that some groups were controlling crucial resources (Henry, 1989).

An early study of 17 skeletons from the burials at Hayonim Cave by Smith (1973) suggested that the occurrence of third molar agenesis indicated significant inbreeding or endogamy (Henry, 1989). On the other hand, recent studies of the Hayonim Cave burials have not confirmed the earlier study (Belfer-Cohen, 1988).

6.4.08 Decoration

Decoration becomes quite common in the Natufian, and the forms of decoration include items for body adornment (such as pendants and beads for headdresses, necklaces, arm bands, leg bands, and belts), utilitarian objects that were decorated (such as bone tools that were incised with patterns), and objects that were incised with realistic and stylised zoomorphic motifs (Sellars, 1998). Animal and human figurines are included among the Natufian decorative items (Belfer-Cohen, 1991).

6.4.09 Groundstone

There is a dramatic increase in the quantity and variety of groundstone objects in the Natufian (Sellars, 1998). This increase in groundstone is interpreted as indicating a greater reliance on cereal grains as well as higher levels of sedentism (Sellars, 1998). The argument for increased sedentism seems to be supported by the presence of non-portable objects such as bedrock mortars at a number of sites (Henry, 1989; Sellars, 1998). The mortars and pestles are the most visible of the groundstone objects, but mullers, plates, bowls, shaft straighteners and whetstones are present as well (Belfer-Cohen, 1991). The most characteristic of the Natufian groundstone objects is the deep mortar that is sometimes referred to as a "stone pipe" (Henry, 1989). Experimental studies have indicated that these deep mortars are more suited to the processing of nuts than to the processing of cereal grains (Henry, 1989).

6.4.10 Hearths

In the Natufian the Hearths have become an integral part of the structures. Most dwelling structures have a central hearth, and the hearths are often elaborately constructed with associated stone slabs or pavements (Redman, 1978).

6.4.11 Middens

In the Natufian there seems to be a high incidence of disposing of refuse in abandoned structures.

6.4.12 Ochre

Ochre is quite common in Natufian contexts, but very little can be said about the uses of ochre in the Natufian.

6.4.13 Pits

In the Natufian pits become a prominent aspect of some sites. Some pits are lined with stone, clay, or even plaster (Henry, 1989). Pits were apparently used for storage, disposal of refuse, and even burials (Henry, 1989). Pits are typically located outside in the open spaces between structures (Redman, 1978).

6.4.14 Settlement Patterns

In the early Natufian sites were concentrated in the Mediterranean zone of the Levant, and this provided the Natufians with access to seasonally abundant food resources such as cereal grains and nuts (Betts, 1998). By the late Natufian there are sites in the black Desert, such as Khallat 'Anaza, that display circular huts, bedrock mortars, and terrace walls (Olszewski and Coinman, 1998). This is significant because there are no identified Upper Palaeolithic sites and few Epipalaeolithic sites before the Natufian in this region (Olszewski and Coinman, 1998).

The coastal plain is devoid of Natufian sites, and this may be the result of rising sea levels, which would have obscured any sites that had been placed along the ancient shore (Valla, 1995). Most Natufian sites have been located in the modern core Mediterranean zone (Sellars, 1998). Palaeoenvironmental studies have demonstrated that the Mediterranean zone was larger during the Natufian than it is today (Sellars, 1998). This may be one of the factors that could explain why the geographic range of the Natufian includes the Negev on the West, Lebanon and Northern Syria on the North, Eastern Syria on the East, and Southern Jordan on the South (Sellars, 1998).

Many Natufian sites (especially the larger ones) are located near permanent waters sources and are situated to provide easy access to a variety of environmental setting, typically between wooded slopes and open grassland (Sellars, 1998; Henry, 1989).

Natufian sites display a vast range in size, from sites as small as 15-100 square meters to sites that are well over 1000 square meters (Sellars, 1998). Bar-Yosef (1981) explains this variation in site size along functional lines. The smaller sites could be seasonal and/or resource exploitation sites, and the larger sites could represent more sedentary basecamps (Sellars, 1998). Henry (1981) provides a slightly different interpretation. To Henry the large sites represent permanent residential occupations, and the smaller sites, which were thought to be located radially around the residential sites, represent non-residential resource exploitation sites (Sellars, 1998). A third possibility is explored by Belfer-Cohen. The large Natufian sites may be the result of seasonal or annual aggregation, which would require seasonal or annual abundances of food (Belfer-Cohen, 1991 [see also Copeland, 1991]).

6.4.15 Social Complexity

Social complexity is a topic that is nearly always associated with the Natufian. It can be argued that dramatic changes in behaviour occurred with the advent of the Natufian, and such drastic changes should be accompanied by changes in the complexity and organisation of social interaction. The Natufian displays such a dramatic change compared to the earlier Kebaran and Geometric Kebaran that Garrod (1957) interpreted the Natufian as a distinct and intrusive culture with an unknown origin (Henry, 1989). It is now generally agreed that the Natufian evolved from the local Geometric Kebaran, and it can be explained as an expression of passively acquired knowledge that was the result of curiosity (Belfer-Cohen, 1991).

Social complexity in the Natufian has been argued from a number of perspectives. Belfer-Cohen (1991) interprets the new forms of symbolic representation in the Natufian as an indication of increased social complexity (see also Henry, 1989), and K. Wright (1991) sees social complexity in the advent of new technologies (Lieberman, 1993). For Valla (1991) social complexity is evident in the larger and more differentiated sites, and D. Bar-Yosef (1991) infers increased social complexity based on an interpretation that Natufians had increased trade (Lieberman, 1993). G. Wright (1978) used the data from Natufian burials to argue for social ranking and inherited status among the Natufians (Lieberman, 1993).

Many explanations for the advent of social complexity have been proposed. Bar-Yosef and Belfer-Cohen (1992) used population pressure that was argued to have been caused by a climatic fluctuation as the basis for their argument about social complexity in the Natufian. Around 13,000 BP the territory available for hunter-gathers seems to have dramatically reduced in size due to rapid global cooling at that time (Bar-Yosef and Belfer-Cohen, 1992 [see also Ronen and Lechevallier, 1991]). Bar-Yosef and Belfer-Cohen argue that this increased the population density within the habitable zone, and this density forced increased competition for resources, which resulted in territoriality, defence of resources, and reduced mobility (Lieberman, 1993). The main problem with this argument is that the data is not sufficient for demonstrating a correlation between climatic change and the advent of the Natufian (Bar-Yosef and Valla, 1991).

A problem that is inherent to many of the arguments about the social complexity of the Natufian arises from the definition of terms such as "sedentism" (Bar-Yosef and Valla, 1991). The appearance of the "house mouse" and other commensals in higher frequencies in the Natufian sites can be used to argue for increased sedentism (Bar-Yosef and Valla, 1991). Increased sedentism is also proposed using gazelle tooth cementum (Lieberman, 1993), and age analysis of Natufian gazelle samples (Davis, 1983) has also been used to propose sedentism in the Natufian (Bar-Yosef and Valla, 1991).

6.4.16 Intra-Site Spatial Organisation

Intra-site Spatial organisation in Natufian sites encompasses many new features. For example, structures, pits, and burials were not common aspects of earlier occupations. Henry (1989) suggests that organisation of Natufian occupations is not well understood, but that that both a linear pattern of structures and a clustered pattern of structures can be discerned. At Mallaha the organisation of structures seems to have change from linear to clustered, but this is not a common occurrence at Natufian sites (Henry, 1989).

In the Natufian the dwelling structure becomes another level at which intra-site spatial organisation can be analysed. Hearths and other installations seem to integral parts of the large structures that are found at Natufian sites. For example, at Mallaha structures typically contain hearths and bedrock mortars, and some of them contain installations such as paved floors or platforms.

6.4.17 Subsistence

Contrary to earlier claims that the Natufian represented the first farming villages in the Near East (Garrod, 1957; Unger-Hamilton, 1989) it is now generally accepted that the Natufians were fundamentally hunter-gatherers (Maisels, 1990; Belfer-Cohen, 1991; Lieberman, 1993).

The Natufian is typically characterised by sedentism, storage facilities, and a focus on subsistence resources that provide storable seasonal abundance (Betts, 1998). The most important of the seasonally abundant resources were the cereal grains and the nuts (especially acorn and pistachio) (Betts, 1998). This form of subsistence is sometime referred to as "pre-agricultural" (Sellars, 1998).

The emergence of the Natufian is typically associated with the exploitation of cereal grains (Maisels, 1990), but experimental archaeology has demonstrated that the deep mortars that are characteristic of the intensive food processing activities of the Natufian are better suited to processing nuts rather than grains (Henry, 1989).

Some researchers (Bar-Yosef and Valla, 1991) argue that the Natufian leads directly to the emergence of farming in the Neolithic. From this perspective, understanding the emergence of farming is a matter of understanding how/why the Natufian emerged from earlier hunter-gatherers (Bar-Yosef and Valla, 1991).

CHAPTER 7

APPLYING THE "COMPLEX-SYSTEMS THEORY OF CULTURE" TO ARCHAEOLOGICAL DATA

CHAPTER 7

APPLYING THE "COMPLEX-SYSTEMS THEORY OF CULTURE" TO ARCHAEOLOGICAL DATA

The Complex-Systems Theory of Culture (CSTC) was presented in Chapter 4, and in its present form it represents a conceptual theory. In other words, it is not a formalised or systematised theory, such as Newton's Mechanics. CSTC is fundamentally dependant on Dynamical Systems Theory and the concepts of complex systems, such as information flow. The primary goal of the present chapter is to demonstrate the practical utility of CSTC by using it to engage archaeological data in a conceptually relevant manner. As a theory CSTC must provide the means for repeatable and testable explanations of data, and it must provide the insight that can be used to direct research. One of the ways that CSTC can be used to direct research is by specifying the type of data that will produce the most effective research within this theoretical context.

A significant aspect of achieving the goals of this chapter is inherent in demonstrating that the analysis of data that is founded on a theory-based methodology is fundamentally different from the interpretation of data that is based on a paradigm. The first section of this chapter will consist of an example of an interpretation of archaeological data that is based on a paradigmatic approach that uses an information perspective. The view presented here is that this example represents a typical methodology that is routinely employed by archaeologists to interpret their data, and that it is superficially similar to my theoretical approach because they both engage archaeological data from an information perspective. Fundamentally my research is engaged in synthesising a general theory of culture, and the justification of this enterprise is based on the argument that theories (of the type I have described) have distinct advantages over paradigms. The implication is that archaeological research could benefit immensely from the addition of a theory-based methodology to its standard paradigm methodology. An implication of this view, which is of secondary significance to this thesis, is that an adequate theory of culture could result in a science of archaeology that is every bit as scientific as is physics.

7.1 AN INFORMATION PARADIGM

The concept of information as a fundamental aspect of culture is not new, and information or information flow has been employed in a number of interpretations of archaeological data. There exists a potentially subtle but very important distinction between the analysis that a theory such as the Complex-Systems Theory of Culture (CSTC) can provide and the interpretations that an information paradigm can provide. This distinction rests on the difference between CSTC as an *explanation* of cultural phenomena and a paradigm of information that is merely an *argument* about culture (which is not the same as an explanation of culture). This distinction is subtle because superficially the paradigm methodology and the theory methodology may seem to be saying the same types of things, and researchers employing either methodology may appear to reach comparable conclusions. One way to understand this distinction is to compare Linnaeus' classification system to Darwin's theory of evolution, which is an explanation of the organisation of biological organisms. This distinction is discussed in more detail in Chapter 02, but a brief review is presented here.

The Linnaean system of classification is fundamentally a *description* of the observed order in the organisation of biological variation, and it is based on some explicit *arguments* about the meaning of the patterns that are observed. On the other hand, Darwin's theory constitutes an *explanation* of the observed organisation of biology based on the underlying mechanisms that produce it. Linnaean classification doesn't explain anything; it simply provides a systematic ordering of the diversity observed in biology. As an explanation Darwin's theory is potentially testable, but Linnaean classification is not testable. The fundamental difference is that Linnaean classification is a *subjective argument* about the nature of the organisation of biological variation. Within the context of our subjective experiences subjective arguments can seem to be no different than objective explanations, but they are fundamentally different. Both subjective arguments and objective explanations are required in a well-rounded research methodology, but it is important to be aware of the distinction.

In *Behavioural Conventions And Archaeology: Methods For The Analysis Of Ancient Architecture* Donald Sanders (1990) engages in a paradigmatic methodology to interpret archaeological data from an information perspective. This will be used as an example that is typical of the interpretive methodology that is employed in archaeological research. Sanders work will provide a perspective to contrast the theory-based analysis of archaeological data that will be presented in the subsequent sections of this chapter. Several features are indicative of the paradigm methodology. The first of these features is that paradigms arbitrarily superimpose high-level concepts onto data. This is virtually impossible to avoid because paradigms are subjective arguments. This is part of the circularity of the paradigm methodology. Data is used to select (or construct) a suitable conceptual view (paradigm), and then the paradigm is used to interpret the data that was used to construct or select the paradigm. The paradigm methodology uses a single data set to first select an interpretative context and then it uses the selected context to interpret that same data. This is a completely circular process, which leads to statements about the meaning of archaeological data that cannot be tested.

Sanders constructs an architectural paradigm that is based on a collection of established paradigms. The architectural paradigm is based on work by semioticians, human geographers, ethnographers, architects, sociologists, and environmental psychologists (Sanders, 1990). The common thread that Sanders suggests for these diverse fields of research is that they all argue for a connection between the information embodied in the built environment and human behavioural decisions. Sanders prefers the "Interactive Model", which states that human behaviour influences the organisation of the built environment, and the built environment influences human behaviour (see Altman 1975; Canter *et al.* 1975; Proshansky, Ittelson, and Rivlin 1976a; Rapoport 1976c, 1980d; Lavin 1981; Maxwell 1983). Again, it is important to be aware of the fact that Sanders has selected these interpretative contexts with a specific data set in mind.

It is obvious that Sanders is functioning within a subjective paradigm methodology for a number of reasons. First, Sanders constructs his architectural paradigm by arguing the relevance of a number of other paradigms. Second, Sanders' paradigm methodology is obvious from his list of the seven determinants of the form and use of domestic space. He is employing an information perspective in his interpretation of architecture, but his seven determinants (climate, topography, available materials, level of technology, available economic resources, function, and cultural conventions) are not inherently information categories nor are they presented from an information perspective (which are obvious necessary requirements from the perspective of an information theory). These are obviously high-level conceptual categories that are selected from the subjective paradigms that Sanders has employed to construct his architectural paradigm. In contrast, by employing an information theory, architecture could be analysed from the perspective of functional constraints and cultural constraints. The functional constraints would best be stated in terms of knowledge of climate, materials, location, etc., and the construction of the architectural feature would display certain aspects of the information used to construct and place the feature in a suitable place.

The cultural constraints would also be specified from an information perspective if Sanders were employing an information theory of architecture. In contrast, Sanders' architectural paradigm uses the "World View" paradigm to assign cultural significance to the form of architectural artefacts. The "world view" paradigm is presented as a concept of culture where the stable cultural group sets ideals that limit the actions, choices, and decisions of group members (see Lynch, 1960; Rapoport, 1977; Greenbie, 1978) (Sanders, 1990). The mechanisms of the "world view" paradigm are high-level concepts such as "value judgments", "expectations", "cultural conventions", and "conceptual attitudes", which are used to argue that cultures constrain the individual in specific ways.

The most obvious aspect of Sanders' endeavour is the use of analogy as the foundation of his interpretation of architectural artefacts. Sanders chooses semiotics for his fundamental analogy. Sanders states that the aim of semioticians has been the study of sign systems within social contexts to understand the codified conventions on which the process of signification is based. Sanders argues that "culturally codified conventions" is one of the seven determinants of domestic architecture. Sanders builds on this analogy by stating that "architecture, like language, is comprised of a system of signs for the communication of information" (Sanders, 1990: 46). Analogy is not a valid basis for explaining a phenomenon. Analogy is simply a form of description or, at best, a part of an argument to reinforce a stated perspective, but the underlying mechanisms of a phenomenon cannot be exposed by employing an analogy.

Sanders employs his interpretive framework on a single structure within the Bronze Age site of Myrtos, Crete. The interpretation is performed at several levels, and the most specific interpretations are based on four more high-level concepts that Sanders has included in his architectural paradigm. These concepts have been extracted from behaviour-environment studies, and they are *personal space*, *territoriality*, *privacy*, and *boundaries* (Sanders, 1990).

Sanders' interpretations are too complicated and lengthy to review here, but a few examples of his procedures will be sufficient to demonstrate his methodology. Sanders begins by selecting a portion of the site that he suggests is best suited to his analysis. Sanders begins his analysis of Block B by using ethnographic analogy to interpret it as a residential structure. This first step excludes his analysis from being repeatable or testable. There is no explanation of why analogy must be employed at this juncture in the interpretation or why analogy is a valid aspect of interpretation. In other words, the paradigm employed by Sanders does not constrain him to employ ethnographic analogy at this juncture, nor does it validate his use of analogy. Any number of researchers could attempt to duplicate this interpretation employing Sanders' architectural paradigm and they could each select a different analogy or choose not to employ analogy at all. The vast number of subjective choices that paradigms afford a researcher fundamentally renders them untestable and non-repeatable.

After identifying the structure as a residence Sanders deploys a number of concepts to interpret the meaning of the spaces of the residence. For example, residences can be said to contain a number of "co-presence zones":

Sounds – 30.2 m is approximately the limits of sounds
Smells – 9.1 m is the approximate limit of odours
Interpersonal zone – 0.9 m is the approximate limit
People-to-architecture buffer zone – 1.5 to 3.0 m
Reach-with-a-tool zone – 2.7 m is the approximate limit

One phase of Sanders' interpretation consists of employing these "zones" to explain the form or function of aspects of the architecture of Block B, and to access what these zones can tell us about "personal space", "territoriality", "privacy", and "boundaries" as they are instantiated within the architecture of Block B.

This methodology is unconstrained, and Sanders is able to choose whichever "zone type" seems to be significant to the architectural feature he is interpreting at the time. A theory-based methodology would constrain the interpretation. For example, a theory should explain which zone type takes precedence during a particular level or phase of interpretation or for a particular architectural feature. Because Sanders is free to choose between a number of interpretive devices as he sees fit his interpretation is not repeatable nor is it testable.

It should be obvious that Sanders presents subjective arguments to construct a paradigm within which he can formulate his interpretations. His paradigm does not provide an explanation of how information becomes embedded in artefacts, nor does he explain how any information that is in artefacts affects the behaviour of the users of these artefacts (or of the archaeologists who investigate them). His paradigm does contain a complicated number of concepts and arguments about how these concepts interact to produce the effects he is interested in employing in his interpretation. On the other hand, it is virtually impossible to demonstrate that these concepts and interactions have any objective meaning. The interpretation produced by Sanders represents yet another particularistic view of archaeological data. In other words, the interpretations offered by Sanders are not repeatable, and they are not testable.

7.2 INTERPRETING THE NATUFIAN DATA

When the Natufian was first described by D.A.E. Garrod (1932), it was initially interpreted as the first instance of sedentary village farming in the history of the world (see Bar-Yosef and Belfer-Cohen, 1991: 186). Some researchers suggested that, as such, it would have been an example of complex stratified social organisation (Henry, 1989: 209-210; Cohen, 1992; Olszewski, 1991; and Perrot and Ladiray, 1988 [from Byrd and Monahan, 1995]). In resent years several attempts have been made to address these claims, but all of them are based on a methodology that employs subjective paradigms that are similar to the Sanders (1990) example presented above. In other words, these attempts have been more or less conjectural and based on a methodology of free interpretation of the data, which is indicative of a paradigm methodology.

Complex-Systems Theory of Culture (CSTC) represents the first theory-based methodology that can be used to address these issues. The site of Mallaha is the largest extensively excavated and published Natufian site to date. This provides a large data set that can be used to test some of the early statements about Natufian life ways and at the same time demonstrate the practical utility of CSTC for archaeological research.

Sanders employed a paradigm methodology to interpret social organisation, and his approach to interpretation allows him to engage the data from any perspective he chooses. CSTC is an explanation of culture, and to use it to interpret archaeological data requires that the interpretations be framed in terms that are relevant to the mechanisms that are used to explain cultural phenomena (i.e. organised patterns of information and information flow). In other words, Sanders used the data that was to be interpreted to select the interpretative context. In contrast CSTC has been constructed on independent data sets (provided by ILT and DST) and not the one that is to be analysed.

CSTC is based, in part, on Dynamical Systems Theory, and it treats culture as a complex self-organising system. In this context cultural processes are dependent on the flow and accumulation of information. There are several aspects of information flow and accumulation that are important to archaeological investigation, and at least two of these can be addressed within this theory. First, an important aspect of understanding past behaviour and culture is the ability to identify the distinction between information that is constrained at some level of social interaction from the information that is subject to individual manipulation. Second, much of archaeological research is dependent on the ability to identify the nature of the social structure of a past culture. CSTC provides the basis for analysing the information flow that is evident in material culture to infer the nature of past social organisations, which includes the means for identifying and discriminating between some aspects of the personal and social spheres of knowledge.

7.3 LEVELS OF COMPLEXITY

The general discussion of complexity in cultural systems is contained within Chapter 4. The following discussion of the complexity of information flow is provided specifically to aid the analysis of Natufian data, and it will refer back to the discussion in Chapter 4 as needed.

7.3.01 First Level Of Complexity

The first level (the lowest level of complexity) of information flow is illustrated in Figure 4.16 and represents homogeneous information flow. The knowledge and behaviour of each individual that is part of the socially constrained domain of the group will be relatively similar due to the relatively high degree of similarity of information that flows to each individual (due to the high degree of interaction between all of the members of the group). Information and behaviour that is outside of the social domain will not be constrained and can vary freely. Evidence for relatively uniform behaviour within a group marks that behaviour as being part of a system of homogeneous information flow that is constrained within an undifferentiated social domain. In other words, patterns of similarity of behaviour and material culture are indicative of shared information through *group* activities, and unique variations that are distinct from the patterns of similarity are indicative of *individual* variation.

Relatively uniform information flow within a group does not mean that every one in the group is always engaged in the current activity of the group. For example, some activities of the group may be dominated by a division of labour based on age so that there will be some activities that are typically performed by the youths or the elders of the group. Everyone in the group will be familiar with the information content of these activities because they are typically performed in full view of other members of the group, and in the case of the activities relegated to the young the adults will be familiar with them from their youth. This will also hold for divisions of labour along other lines, such as gender.

7.3.02 Second Level Of Complexity

The second level of complexity of information flow is represented by the interaction of the two sub-groups shown in Figure 4.18. This could hypothetically represent the occupation of two houses within a settlement. In this hypothetical example Sub-Group A represents the members of House 1 and Sub-Group B represents the members of House 2. The yellow and blue individuals move freely between these two houses and participate in the activities of both houses even though each of these two individuals is formally a member of only one of the houses (yellow with House 1 and blue with House 2). The participation of these two individuals in all of the activities of the two houses maintains adequate information flow between the two houses to keep the knowledge (and therefore the behaviour) of all the individuals of both houses on similar trajectories. Without this information flow the knowledge and activities of the two households would immediately begin to diverge on distinct trajectories. This second level of complexity displays homogeneous information flow similar to the first level of complexity, which may make it very difficult to distinguish from the first level of complexity within the archaeological record. Nevertheless, if the archaeological data is sufficiently fine-grained even these two levels of social organisation may be discernable.

7.3.03 Third Level Of Complexity

The third level of complexity of information flow is represented by the interaction of Group 1 with Group 2 that is shown in Figure 4.20. At this level of information flow the membership of Group 1 and Group 2 is completely exclusive (in other words, none of the members of Group 1 are members of Group 2, and none of the members of Group 2 are members of Group 1). The information flow at this level is not the type of participant interaction displayed within the sub-groups or between the sub-groups that are shown in Figures 4.16 and 4.18.

A hypothetical example of differentiated information flow could be represented by the condition where Group 1 and Group 2 represent two households within a site that maintain an exclusive identity for activities that take place within the individual houses. In this example the members of each house have preferential access to the distinct knowledge that is part of activities that only occur within the confines of their house. On the other hand, any activities that occur outside of the house will result in information flow between the members of both houses (designated as Group 1 and Group 2). Whenever members of these two groups are in close proximity to each other the interactions between the two groups is constrained by the form of the relationship that exists between the individuals shown in the diagram. The important distinction between the third level and the first two levels is that in the third level of complexity members of the two groups participate in at least some activities that are distinct from the other groups – the activities that occur exclusively within the houses.

For example, lithic technology may be a category of behaviour that is confined to the interior of the houses, but the use of lithic tools may be a part of activities in which members of both houses participate. In this case it would be expected that each house would display distinct and identifiable reduction traditions, but both houses would produce similar classes of end objects. In other words, the tools produced in both groups would remain very similar, but the reduction sequences would be distinctly different. At this level it is sufficient that the use of tools in both groups contain an adequate overlap in similar techniques and strategies to allow them to function together in the necessary tasks. This does not mean that their behaviour need be nearly identical in total.

CSTC provides the means for explaining social organisation from the perspective of information flow. The third level of information flow is the point at which members of each group have privileged access to information that is not available to members of the other group. For example, they can all see the finished products of activities (i.e. structures, pots, flints, clothing...), but because they do not jointly participate in the activities that produce them they will not have access to the specifics of production. In this case both groups may produce very similar items, but the similarities will be strongest in the finished item. The specific steps for producing the items will differ from group to group, and the differences in production will increase with the complexity of the method of manufacture and the length of time that the production units have been separated.

7.4 NATUFIAN ARCHITECTURE AT MALLAHA

This section begins the analysis of the Natufian data at Mallaha. The interpretation presented here is based on CSTC, which makes it a theory-based methodology. This means that the theory constrains the interpretation to follow a specific form. Information flow is the fundamental mechanism that constitutes the explanatory basis of CSTC. This means that interpretations that are based on CSTC ***must*** ultimately be framed in terms of information flow.

CSTC explains cultural phenomena from the perspective of information flow, but archaeological data is static, therefore information flow must be inferred from the patterns of information that are inherent to the material residues of past cultures. This methodology is distinctly different from a paradigm-based interpretation such as the Sanders (1990) example presented above. Sanders could employ any of quite a large number of perspectives for his interpretation, which demonstrates that paradigms do not constrain interpretive methodology as do theories.

Sanders (1990) engaged architectural interpretation from the perspective of a subjective paradigm that represents architecture as a symbolic construct that contains social information and meaning. By employing a ***theory*** that ***explains*** culture I do not have to assume that structures contain social symbolic meaning. In other words, CSTC allows researchers to analyse architecture to determine if the information that is inherent to the structures is constrained by social mechanisms. CSTC also allows the researcher to specify some aspects of the social meaning that existed in the structures for the people who built and occupied them.

7.4.01 Structures And Social Organisation

The presence of large permanent structures, such as those found at Mallaha, is one obvious aspect of Natufian sites that could represent the foundation of structured information flow and social differentiation. In pre-Natufian sites evidence suggests that structures were not often constructed and when they were they were typically small and constructed of ephemeral materials (e.g. Ohalo II - Nadel and Werker, 1999). Evidence for activity centres at these sites typically occur near one of the hearths that are typically placed outside of structures in a relatively central location within the site. In this configuration activities are displayed in full view of everyone at the site and information flows uniformly to all members of the group and all persons at the site. This organisation of activities within a site clearly represents Level One Complexity as discussed above.

At Natufian sites, such as Mallaha, the structures represent a possible block to information flow. If some activities were performed only inside the structures (or only in a specific structure) then this would be evidence that this activity may have been restricted to a sub-group of the site and differential information flow could be occurring. The data from Mallaha shows that many structures, such as number 26 (see Figures 7.08-7.03), display evidence of chipped stone production, groundstone production, woodworking, bone working, and food processing, and evidence of these activities is also found outside of the structures. Superficially this suggests that a broad range of activities are performed in many contexts within the site, and the most likely interpretation of this data is that there is not differentiated information flow at Mallaha because all activities are being engaged uniformly across the site, which produces homogeneous information flow. This pattern of information could represent either level one or level two complexity of information flow as described above.

This initial analysis of the patterns of information at Mallaha is very general, and it reflects the nature of the data that has been collected and published. What it indicates is that the patterns of information are similar when comparing the data inside the structures to the data outside of structures, and when comparing data from inside one structure to the data from inside any other structure. This similarity of information indicates that the social organisation at Mallaha was relatively inclusive at the site level. If there had been a differentiated social organisation at Mallaha then CSTC could be used to predict that more than one pattern of information would be evident. For example, if the structures represented proprietary residential units then each one should develop divergent patterns of information for the activities that are restricted to the residential structure. The walls of the structure would block the direct flow of information between inside and outside, and the exclusivity of the residence would block indirect flow of information between one structure and any other structure. The data at Mallaha displays Level One Complexity and not Level Three Complexity, which indicates that there was not a differentiated information flow at the site.

Structure 26 (shown in Figure 7.01) has not been the focus of a detailed study, but Perrot (1966)[1] does describe some of the contents of this structure. Figure 7.01 shows that Structure 26 contained at least one hearth (Figure 7.01: 46), which was bordered on at least two sides by stones, and a bedrock mortar (Figure 7.01: 37). Pestles are shown in squares L13-15. Beads (shell and bone), lithic debitage, groundstone, and ochre were also present within this structure.

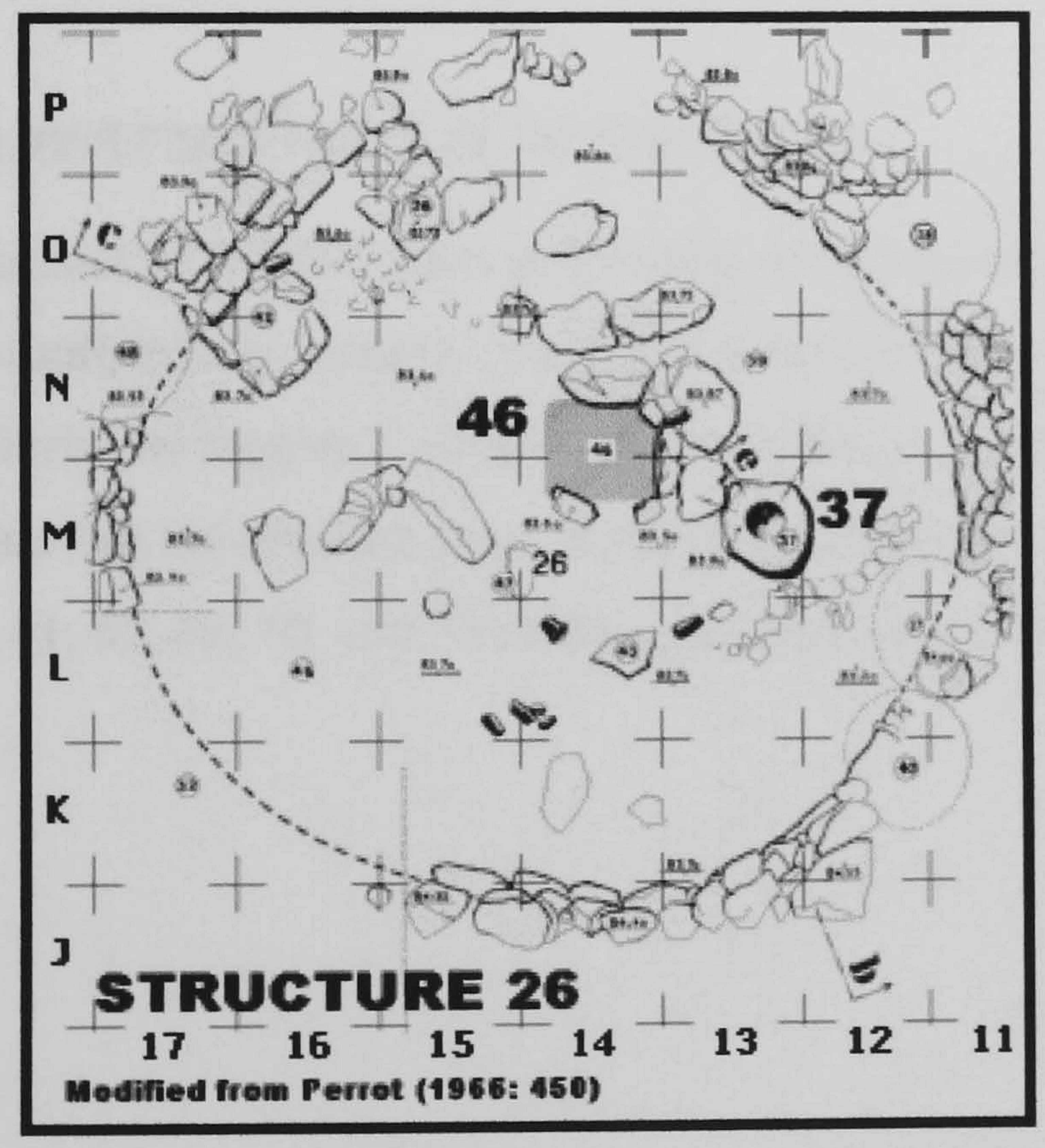


FIGURE 7.01 – A diagram of structure 26 that shows the common features of the structures at Mallaha. These include circular shape, walls faced with unmodified stone, no internal partitions, a central constructed hearth (46), and groundstone facilities (37). (Modified from Perrot, 1966)

[1] Perrot et al. (1989) may be the definitive publication on Mallaha, but it is not contained within the library at The University of Liverpool, and it is not available through the Inter-Library Loan system.

The nature of the data published on these structures will only allow a superficial analysis, but at this time the only conclusion that can be supported by the data is that the structures were used as activity locations for a broad range of behaviour and that similar activities were performed in many structures. This condition represents a social organisation at this site that displays homogeneous information flow, and, therefore, was what would be expected of an egalitarian system and not a hierarchical system. Due to the nature of the data and the level of analysis this conclusion can only be considered to be fragile at best. Therefore, several more aspects of the site of Mallaha will be subjected to analysis to determine if they can be used to support or refute this preliminary conclusion. This data from Mallaha indicates that the structures did not represent a barrier to information flow nor did they significantly structure information flow by partitioning behaviour into distinct proprietary locations. A more detailed analysis and comparison of the materials from the interior of the structures at Mallaha could possibly demonstrate a pattern of differentiated information from structure to structure, but until such an analysis is undertaken the data that is available indicates uniform information content in all structures, which suggests uniform information flow across the site.

7.4.02 Construction Of Structures

The construction of the structures at Mallaha provides another data set that can be analysed for information content to see if information flow is homogeneous or differentiated. Referring to Figures 7.02 and 7.03 the structures display a number of features that indicate that information flow on the site is homogeneous. Structures 26, 29, 41, 51, 56, 61, 62, 66, 70, and 73 display the consistent features shown in Figure 7.04.

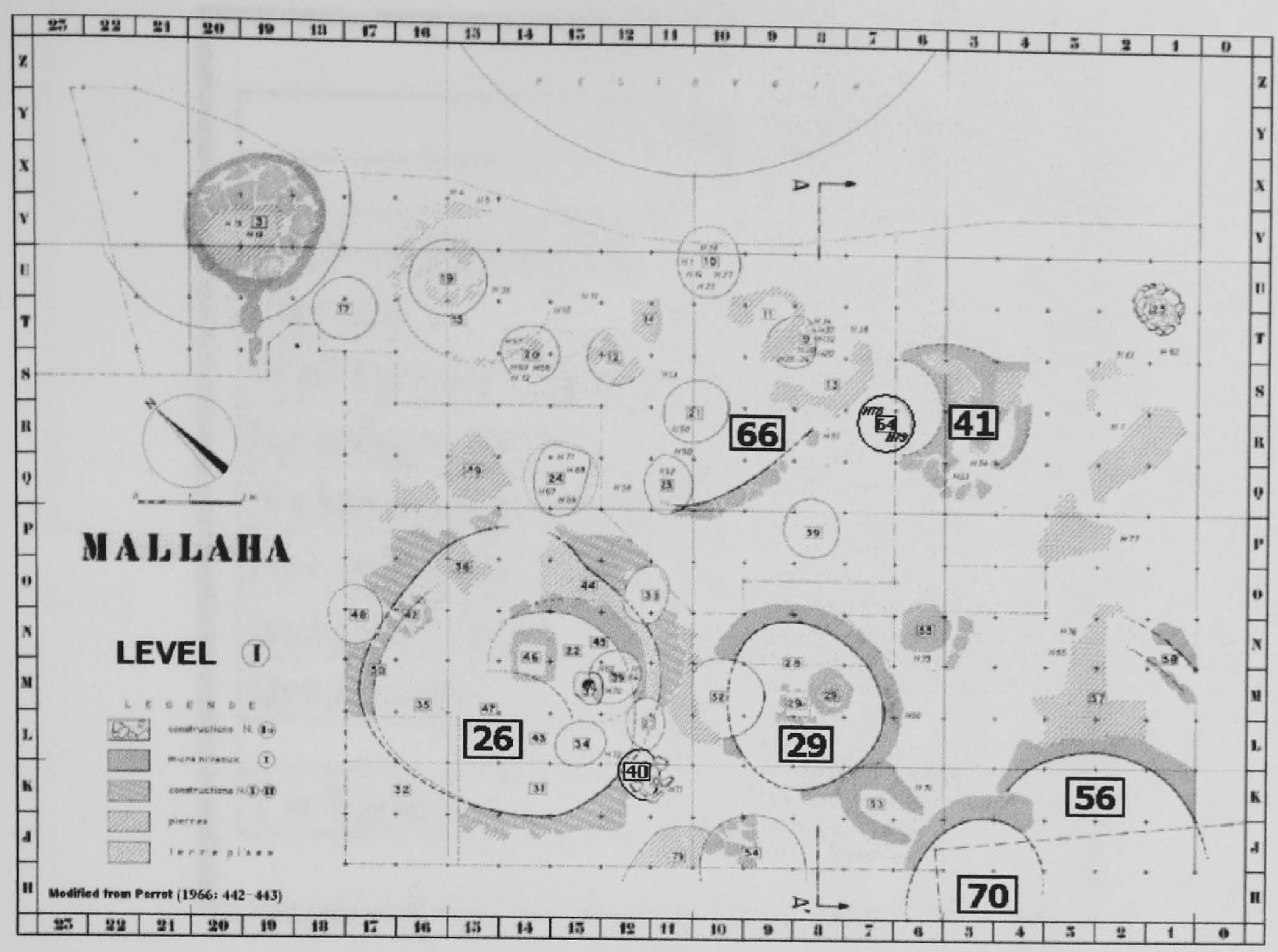


FIGURE 7.02 – Plan of the structures found in Level 1 at Mallaha. (Modified from Perrot, 1966)

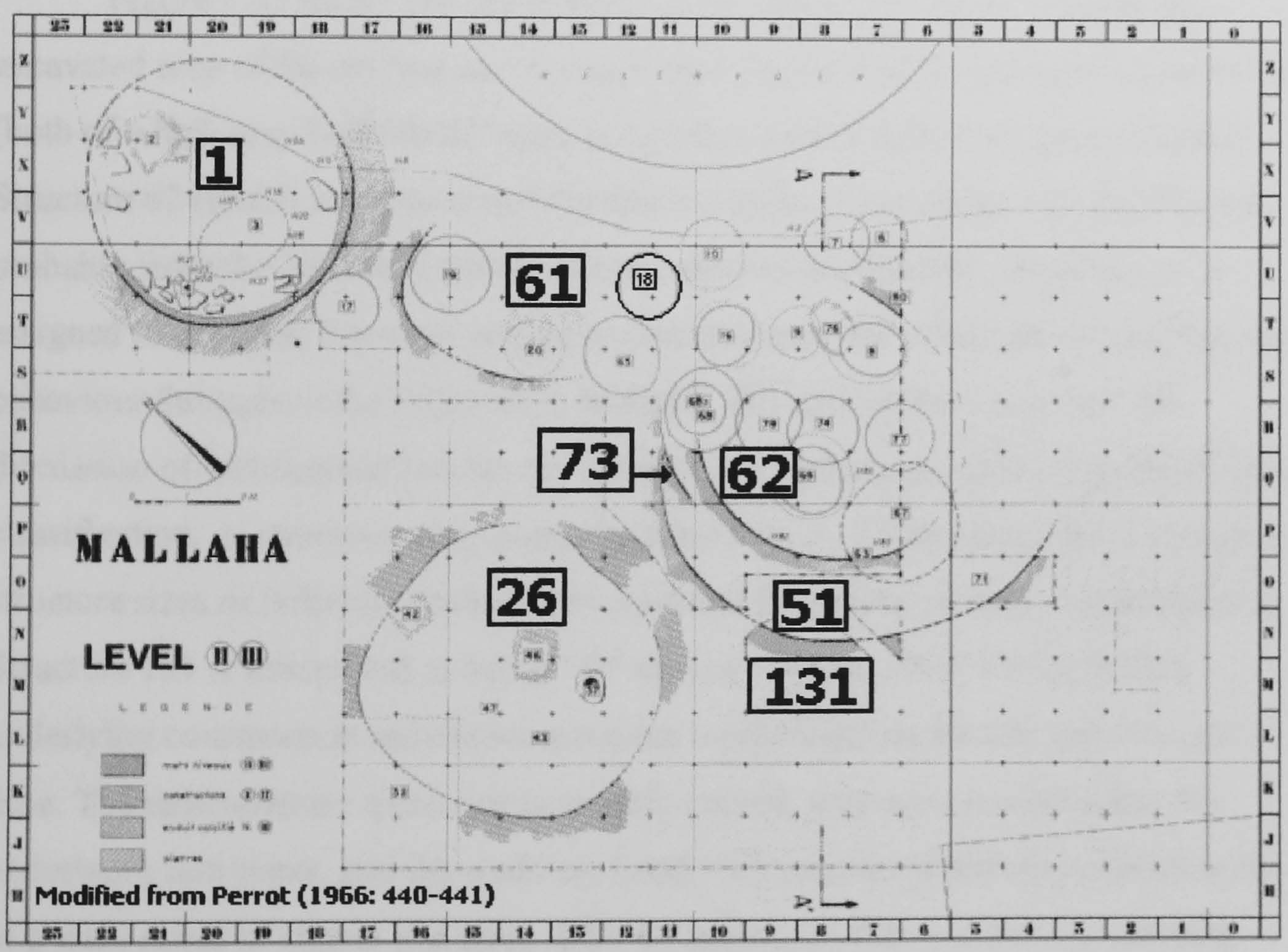


FIGURE 7.03 – Plan of the structures found in Levels 2 and 3 at Mallaha. (Modified from Perrot, 1966)

	Mallaha	Ohalo II
Semi-subterranean	T	
Circular	T	
Wall faced with stone	T	
Hearth present	T	
No internal partitions	T	T
Not subterranean		T
Irregular shape		T
Brush walls		T
T = Typical		

FIGURE 7.04 – A list of the typical features of structures at Mallaha and Ohalo II. Notice that the typical features at each of these two sites forms a recognisable pattern for that site.

Figure 7.05 shows that these features are consistent not only across the excavated area of the site but also through time. Structure 131 underlies structure 51 (both of which may be from different occupation events within the Early Natufian. Structure 62 (which was constructed inside the walls of structures 131 and 51) was probably from the Middle Natufian as were structures 29 and 80. Structure 66 is assigned to the Final Natufian and represents evidence for continuity of construction behaviour throughout the Natufian at Mallaha. It is important to note that this discussion of architecture focuses on construction techniques, rather than typological classification, of structures. For example, there may be distinct patterns of changing structure sizes or individual unique structure configurations present at Mallaha (e.g. Structure 131 is interpreted as being "D" shaped – Valla, 1990; 1991), but the underlying construction techniques are quite uniform across the site and through time. The structures are quite symmetrically curved, they are excavated into the underlying sediments, and the walls are lined with undressed and unmortared stones of a wide range of shapes and sizes. DST demonstrates that it is these underlying aspects of complex systems, not their superficial appearances, that are the more critical indicators of the patterns of organisation in information flow. In other words, the structures display a superficial similarity, and even more importantly they

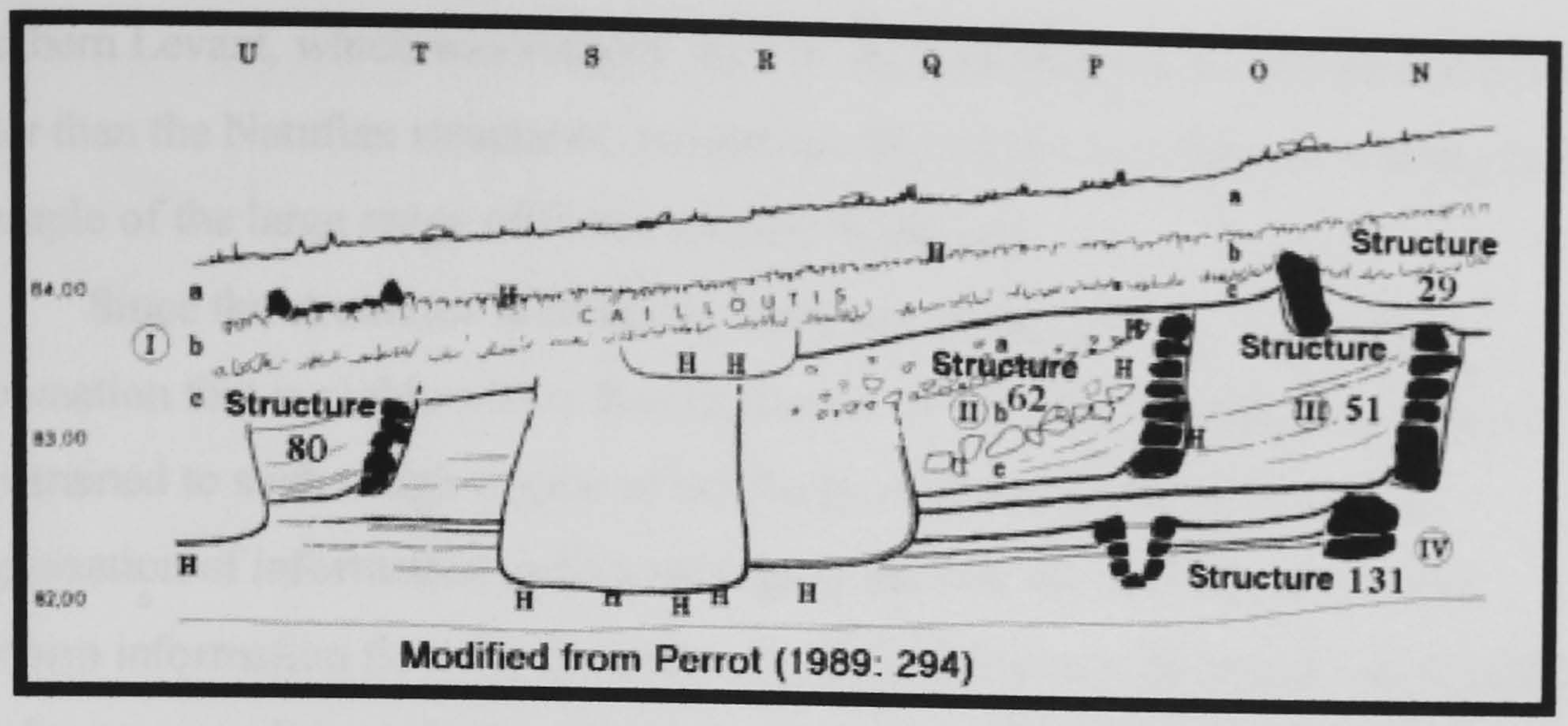


FIGURE 7.05 – A stratigraphical drawing of the sequence of construction events at the location of structure 131 at Mallaha. (Modified from Perrot, 1966)

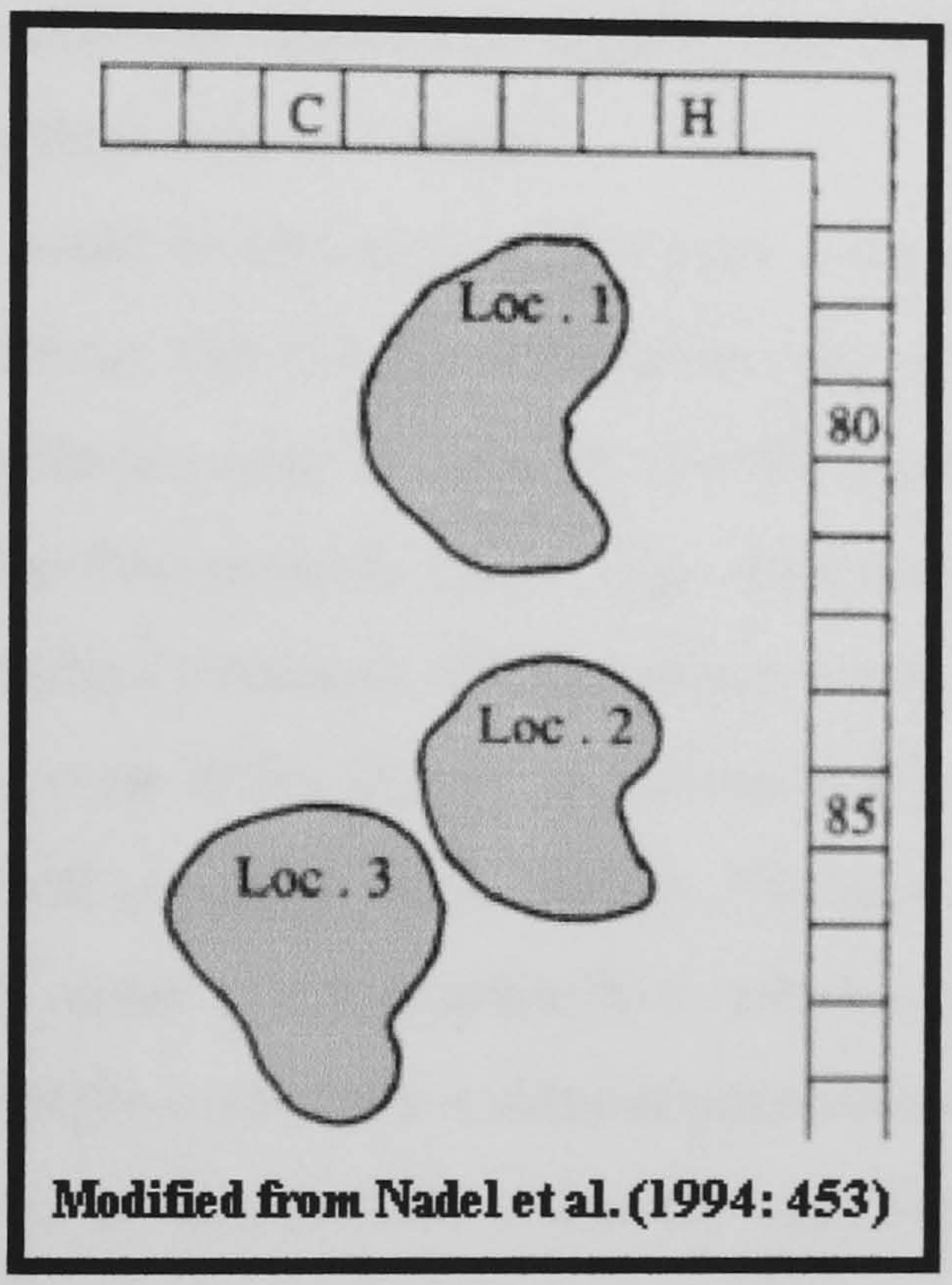


FIGURE 7.06 – Plan of the structures from Ohalo II. They differ from the structures at Mallaha in the following parameters: (1) they are not semi-subterranean, (2) they are irregular in shape, (3) their walls are not lined or supported with stone, and (4) they display a significant variation in shape. (Modified from Nadel et al., 1994)

demonstrate a high degree of similarity in construction techniques (both synchronically and diachronically).

These common aspects of the structures at Mallaha are not constrained by either environmental or material parameters. For example, Figure 7.06 (and the table in Figure 7.04) shows that the structures from Ohalo II are distinct from those at Mallaha in several aspects. The structures at Ohalo II are from the boundary between the end of the Upper Palaeolithic and the beginning of the Epipalaeolithic in the

Southern Levant, which was roughly 20 kya. As such they are several thousand years older than the Natufian structures, but irrespective of this fact they serve as a good example of the large range of forms structures can take.

Since the structures at Mallaha could vary freely and don't the only explanation that is viable within the constraints of CSTC is that the structures are constrained to such a high degree of similarity of construction by the social organisation of information and knowledge at the site. As such they represent uniform information flow for the entire site. In other words, the structures at Mallaha display two conditions: 1) they display many consistent attributes that suggest that their construction is part of a relatively uniform social knowledge and behaviour repertoire, 2) they display none of the distinct patterned differences that would signal the existence of either a differentiated social organisation or distinct groups of individuals constructing their own structures.

At this point it should be obvious that there is a clear distinction between the paradigm based methodology that is typical of archaeological interpretation as exemplified in the example provided by Sanders (1990), and the theory based methodology presented in this research. CSTC is poorly developed at this time, as can be seen in the non-formal treatment of information, but that can be remedied in the future. Nevertheless, even in this less than sophisticated form CSTC has certain advantages over the typical paradigm methodology. The analysis of Natufian structures is presented in terms of information flow, which constitutes the mechanism that CSTC employs to explain cultural phenomena. The implication is that this analysis is repeatable and testable within the explanatory context of CSTC. Sanders' paradigm does not present an explanation, and it is not repeatable or testable.

This theory-based methodology has another advantage over the paradigm methodology. The interpretation of the archaeological data from Mallaha that is based on CSTC is constrained to a specific form. This means that all aspects of the data are interpreted in an equivalent form, and they can all be compared and integrated because they are in an equivalent form. Typical archaeological analyses approach each aspect of behaviour at a site from a unique perspective, which renders them incompatible or incomprehensible as a whole. To demonstrate this I will continue to interpret the data from Mallaha by moving on to the burial data.

7.5 BURIALS AT MALLAHA

One of the advantages of a theory-based methodology (over a paradigm methodology) is the unification of perspective. CSTC provides a common perspective for analysing all cultural phenomena – information content and its implication for information flow. Burials represent a distinct type of behaviour and require a specific context for evaluating information content, which will be different in some aspects from the one used for analysing structures and their construction.

To place the burials at Mallaha in a proper context it is necessary to explore the purpose and nature of mortuary practices. First, it is necessary to distinguish between the accidental preservation of an articulated skeleton and an intentional burial. Gargett (1989) discusses the intentionality of burial with respect to the Neanderthals. Drawing on the work of a number of authors (Bouyssonie, Bouyssonie, and Bardon, 1908; Binford, 1968; Drucker, 1972; Harris, 1979; Harrold, 1980; Shackley, 1980) Gargett suggests that intentional burials can be identified by a number of indicators, and that it is not enough to suggest that a burial could have been intentional. The intentional burial must be established by eliminating the possibility of accidental burial, at least to a reasonable degree. The most important indicators seem to be a non-natural position of the body, the existence of an excavated or elaborately constructed grave, and evidence of grave offerings or other ritual activities. All of the arguments involved are based on the presumption that an intentional burial will display information that can be used to identify it as being distinct from accidental burials, and CSTC provides an explanation for this perspective.

One of the criteria that Gargett does not discuss is the issue of multiple burials. The reason that a number of burials indicate intentionality is because they establish a pattern of behaviour, and patterns of behaviour do not happen by accident. Multiple burials that display evidence that they represent a number of discrete events and not one group burial is an important indication of intentional burial in the Natufian, but was probably over looked in discussing Neanderthals because few Neanderthals are found in groups. Once intentionality is established the next issue to be resolved is the question of ritual.

Many researchers have claimed that intentional burial is equivalent to ritual burial, but there are other reasons for intentionally burying the dead. Burial practices could represent a purely functional behaviour or they could be both functional and symbolic. It is not enough to assume that a burial is a symbolic or ritualistic behaviour just because it can be reasonably demonstrated to be an intentional burial. Functional burial practices must be assumed to represent the natural equilibrium condition for humans, and symbolic or ritual burials must be demonstrated to diverge from this condition. This perspective is based on the view that the most fundamental aspects of burial practices are typically functional, and that this represents the most parsimonious explanation of the basic aspects of burials. Symbolic burial practices must be demonstrated as a departure from the equilibrium condition by displaying more information or more complex patterns of information than are required by an explanation that is based on the functional requirements of burials. The first task is to establish the equilibrium condition – the intentional functional burial.

7.5.01 Intentional Burials

For many researchers the presence of a large number of skeletons (105) that are typically articulated and complete (or nearly complete) would be considered to be sufficient evidence that the skeletons found at Mallaha represent intentional burials. The consideration of a number of other aspects of the skeletons makes this conclusion nearly irrefutable. The position of the skeletons indicates the presence of processes other than those that would be expected due to natural mechanisms. For example, the skeletons typically display a degree of flex that represents a pattern that cannot be explained by natural processes. Any individual skeleton could be preserved in a flexed position, but 105 instances of flexed position is clear evidence of a mechanism that cannot be explained by the random processes involved in the natural preservation of the dead. The positioning of skeletons is supported (and partially explained) by the overwhelming evidence that the dead were typically placed in pits. Not only are many of the pits clearly visible, but also many of pits disturbed earlier burials when they were excavated. For example, Pit 3 (containing H15 and H19) disturbed the seven skeletons that were contained in the sediments below the location chosen for the excavation of this pit. The fact that the underlying burials were disturbed by the later burial is evident in the fact that typically the bones from the disturbed burials are interred along with the new burial (as is the case with Pit 3).

No single aspect of Natufian burials is sufficient to demonstrate that they were intentional, but all of these aspects taken together represent a pattern of behaviour that demonstrates that these burials were typically intentional. On the other hand, intentional burials are not necessarily a socially significant or ritual behaviour. The symbolic content of burial behaviour must be established independently of the intentionality of burials because intentional burials could have been purely functional.

7.5.02 Functional Burials

Some researchers tend to conclude that intentional burials are indications of ritual activity. This view does not address the fact that burial could represent a functional solution to a possibly hazardous situation (Kooijmans, 1989). For example, a dead body that is not properly disposed of can be a source of visual and emotional trauma, but it can also become a potential source of disease, noxious odours and fluids, and the dead can attract pests in the form of insects and scavengers of all sizes. Functional disposal of the dead could involve a number of mortuary practices including:

- removing the dead from the vicinity of occupation
- placing the dead on a platform or up in a tree
- placing the dead in an unused cave
- placing the dead down a deep crevasse
- placing the dead in a stream to be carried away
- placing the dead on a boat or raft to be floated out onto a lake or sea
- placing the dead in a tomb or barrow
- cremating the dead
- burying the dead

Some of these possibilities will be avoided because they are prohibitive due to the amount of time or resources consumed. Highly mobile groups may deal with the dead by simply leaving them behind when they move on (although this could involve such practices as placing them in a tree, on a rock out-crop, or on a constructed platform). On the other hand, as mobility decreases mortuary behaviour could no longer rely on such simple solutions for all cases.

Demonstrating that burials contain a symbolic component as well as a functional purpose involves demonstrating that the burials are constrained by social knowledge. CSTC states that social knowledge constrains behaviour to display a relatively similar patterned or structured behaviour due to the self-organising nature of complex systems such as cultures. This means that the symbolic aspects of a burial should display information that indicates a pattern of structured behaviour that cannot be explained by the functional requirements of a burial. For example, it might be argued that the act of burial is symbolic because the "labour cost" of digging a grave is relatively high. From this perspective the act of burial is inherently symbolic because people would not normally engage in unnecessarily high-cost behaviours unless they are socially constrained to do so. Belfer-Cohen and Hovers (1992) suggest that burial cannot be considered to be an expedient form of functional mortuary practice because it would involve far more labour than simply carrying the body an appropriate distance from the occupied localities. On the other hand, extensive excavations in the form of structures and pits are found at Mallaha so it seems reasonable to assume that the labour involved in burying the dead was not prohibitive enough to suggest that "labour cost" alone is sufficient to demonstrate that the act of burial represents a symbolic aspect of mortuary behaviour. In fact, burial in the vicinity of an occupation may be the most expedient method of disposing of the dead at Mallaha, especially when there may have been abandoned structures or pits that could easily have been use for the disposal of the dead. Also, the burials that are found at Natufian sites such as Mallaha may represent only a part of the mortuary practices employed at that time. Deaths that occurred away from occupational localities may have been dealt with in a number of ways and not necessarily buried. Unfortunately the only Natufian mortuary data that is available is provided by the burials that are found at sites such as Mallaha.

7.5.03 Selection Of Burial Locations

From a paradigmatic perspective the grouping of burials could be used to argue that the Natufians engaged in a form of ritual mortuary practice. Some burials at Mallaha are apparently grouped together, and the most convincing evidence for the grouping of burials at Mallaha comes from the two groups that were located under Structures 1 and 131 (which have been designated "cemetery A" and "cemetery B" respectively) (Perrot, 1966).

If burials could be linked to structures then this linkage could represent evidence for a ritual aspect to both burials and structures. For example, if it cold be demonstrated that the burials beneath structures 131 or 1 had been placed through the floor of the structures while they were still in use, then this evidence could be used to indicate a ritual aspect to behaviour that links burials to structures. This aspect of burials could be designated as ritual behaviour because there is no known functional reason for placing a burial through the floor of a structure while it is in use. A single burial through the floor of a structure would represent a unique variation, but a number of burials that are placed through the floor of a structure would represent a pattern of burial behaviour that contains a ritual aspect.

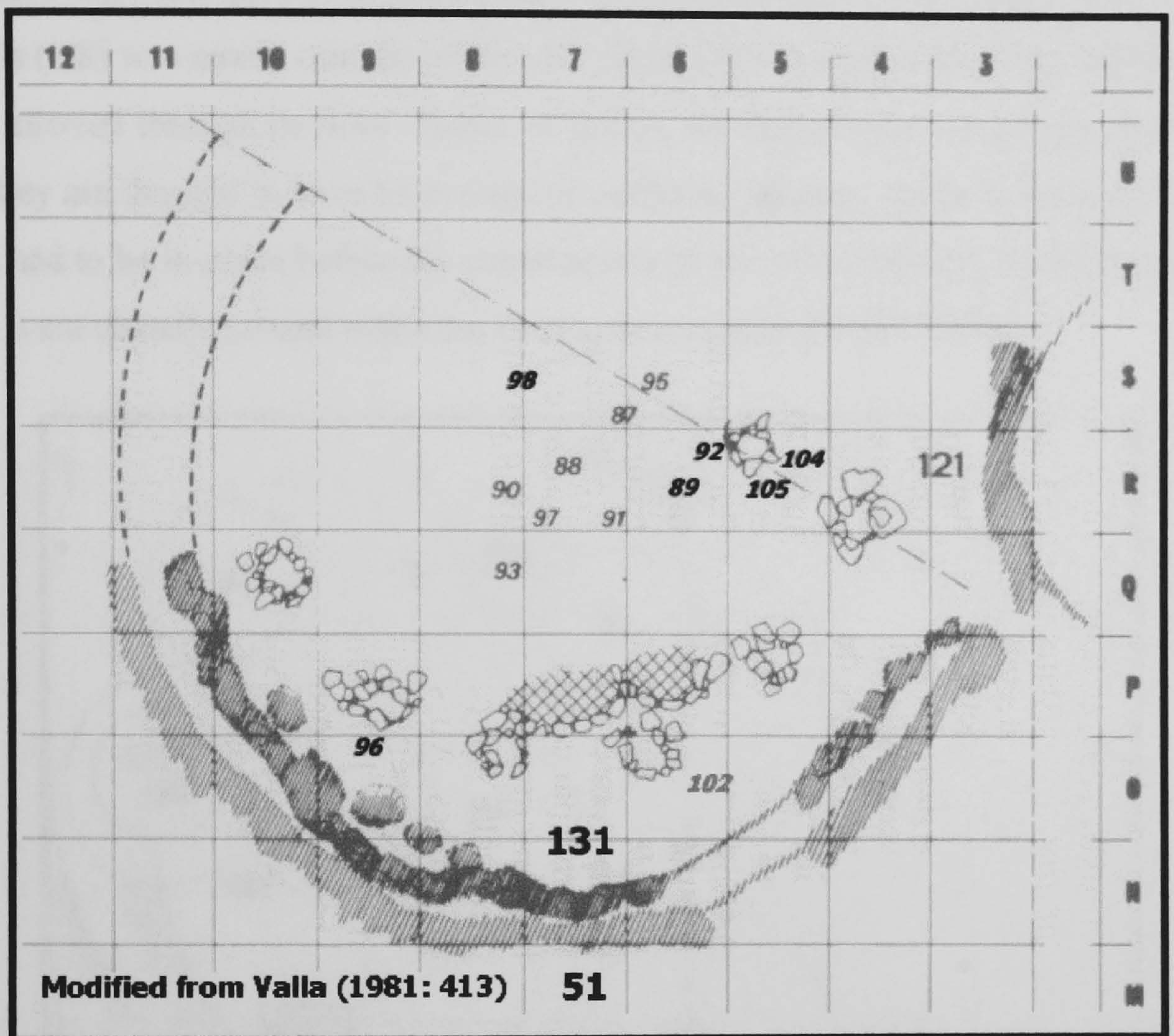


FIGURE 7.07 – Plan of structures 51 and 131 showing the burials found beneath and inside them. (Modified from Valla, 1981)

Figure 7.07 shows the location of structure 131 and the burials that were discovered grouped beneath it. Valla's (1990) interpretation of this structure suggests that the postholes shown in the figure were an integral part of the original construction of the structure. Skeletons 92, 104, 105, and possibly 89 were located beneath the postholes of structure 131, and definitely precede the construction of this structure if Valla's interpretation is correct. Skeleton 98 was placed in the sediments that filled structure 51, but it was located below the hearth (76 in Figure 7.08) of structure 62 that was constructed inside of structure 51 so it must have been placed there after the abandonment of Structure 131. The 9 burials that are located beneath Structure 131 are considered to be roughly contemporaneous so if 4 of them were in place before the structure was constructed then it is likely that none of them were placed through the floor of the structure. Also, there is no evidence to suggest that the floor of this structure was penetrated for burials until after it was abandoned (Valla, 1990).

Of the 10 burials that were located under structure 1 (Figure 7.09), three (H6, H6b, and H8) were positioned so that they were partially beneath the wall of the structure and must have been placed there before the structure was built. One of the burials (H8) was nearly outside of the perimeter of the structure and could not have been interred through its floor. These 10 burials are characterised as a "graveyard", and they are thought to have been roughly contemporaneous. Since at least three of them had to be in place before the construction of the structure then most likely all of them were already present when the structure was built (Perrot, 1989).

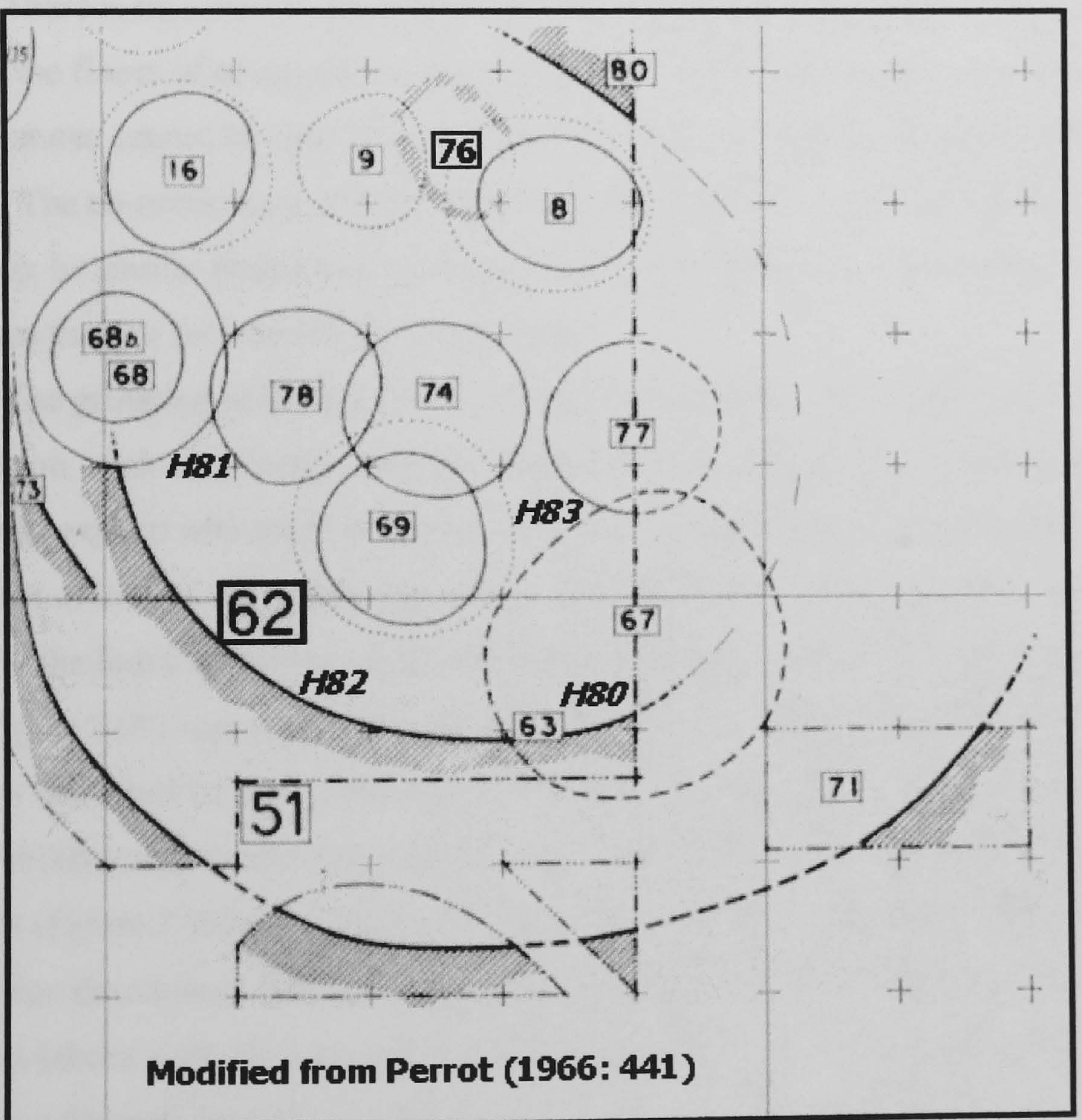


FIGURE 7.08 – Diagram showing the location of the hearth (76) and the four burials that were placed within structure 62 at Mallaha. (Modified from Perrot, 1966)

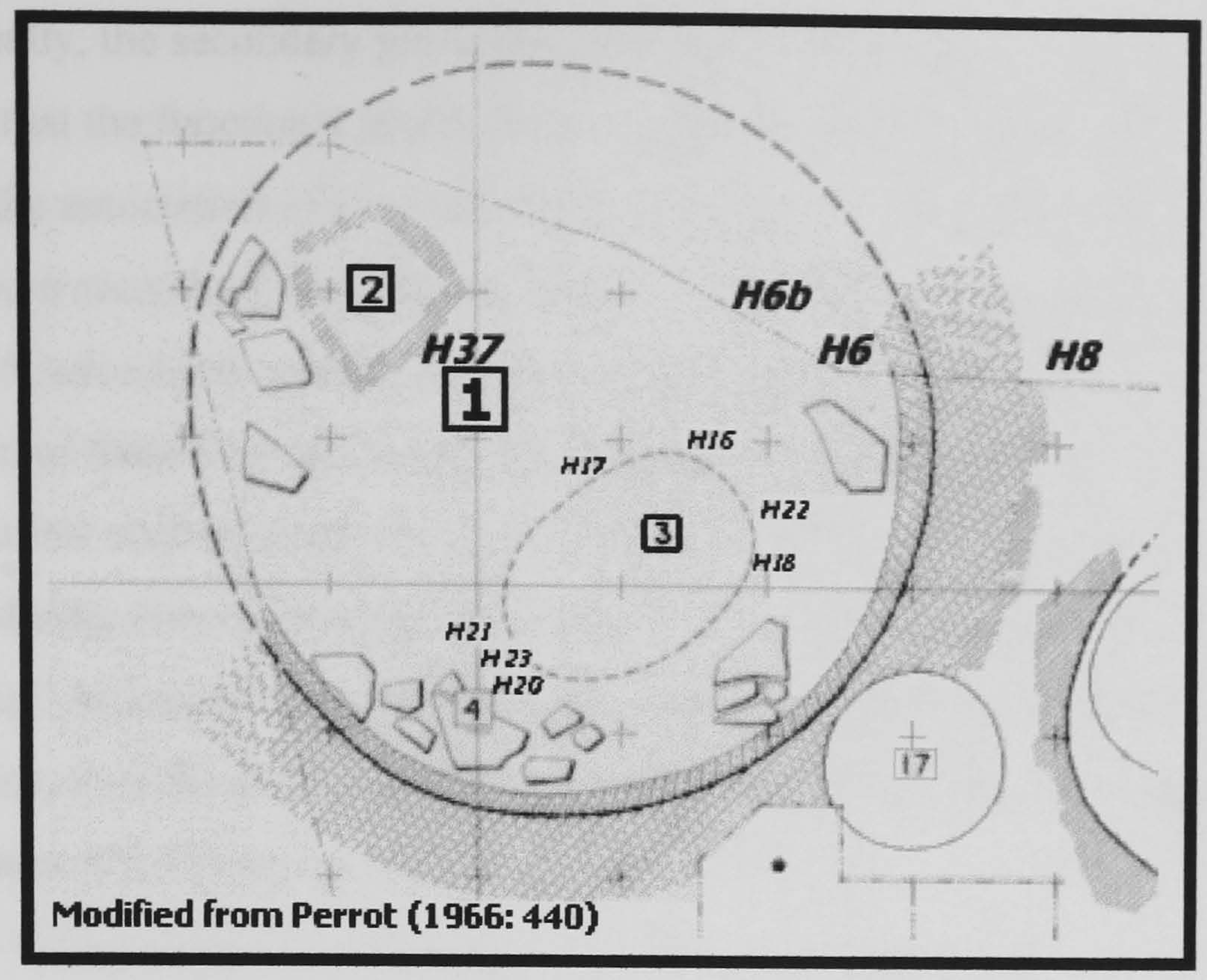


FIGURE 7.09 – Plan of Structure 1 showing the hearth (2), Pit (3), and the 12 burials that were associated with it. (Modified from Perrot, 1966)

There is no evidence to suggest that any of the burials at Mallaha were placed through the floors of occupied structures (Perrot, 1989). The co-occurrence of burials and structures cannot be used to argue that the burials at Mallaha display symbolic aspects. The co-occurrence of burials and structures may be largely accidental or there may be similar functional mechanisms that are common to both burials and structures that are responsible for this pattern.

The grouping of burials into "cemeteries" may have a simple functional explanation, such as relatively loose sediments that are easy to excavate, and this could also explain why these locations were later preferred for structure construction. A number of burials at Mallaha may have been placed in existing pits and some were placed in the loose sediments that filled abandoned structures. For example, skeleton H96 (Figure 7.07) was apparently placed in the sediments that filled structure 51, and was later disturbed by the construction of structure 62, which indicates that H96 was placed in this location after Structure 131 was abandoned. Skeletons H80, H81, H82 and H83 (Figure 7.08) were deposited within the sediments that filled structure 62 after it was abandoned. This seems to indicate that burials at Mallaha were expedient (as far as labour costs are concerned), and this tends to support the view that the grouping of burials may have an expedient functional explanation. Unless this functional explanation can be refuted then the grouping of burials at Mallaha cannot be used to argue for a symbolic or ritual aspect for these burials.

Finally, the secondary group burials from Mallaha may represent another indication that the functional attributes that resulted in the grouping of burials also produced the association of structures and group burials. Four group burials at Mallaha were secondary inhumations. Grave 9 contained 8 individuals, Grave 10 contained 5 individuals, and Graves 20 and 24 contained 4 individuals each. One explanation of these four secondary group burials is that they may have been grouped primary burials such as those that were found in "cemeteries" A and B, but they were disturbed during the construction of structures and reburied together as a single group burial. As long as these functional explanations remain as possible explanations, then the grouping of burials at Mallaha cannot be used to demonstrate a symbolic aspect for these burials.

7.5.04 Deferential Treatment Of Burials

Deferential treatment of the dead could be used to infer ritual that is linked to ancestor worship and inheritance of goods or position. Byrd and Monahan (1995) evaluated the amount of effort displayed in Natufian graves to determine if a pattern of preferential treatment could be discerned, which could be used as indicators of status using concepts presented by Peebles and Kus (1977). Byrd and Monahan indicate that 92% of the 153 Natufian burials that could be evaluated displayed relatively simple grave construction. At Mallaha only one grave (containing two of the 105 burials) displays an aspect of elaborated construction.

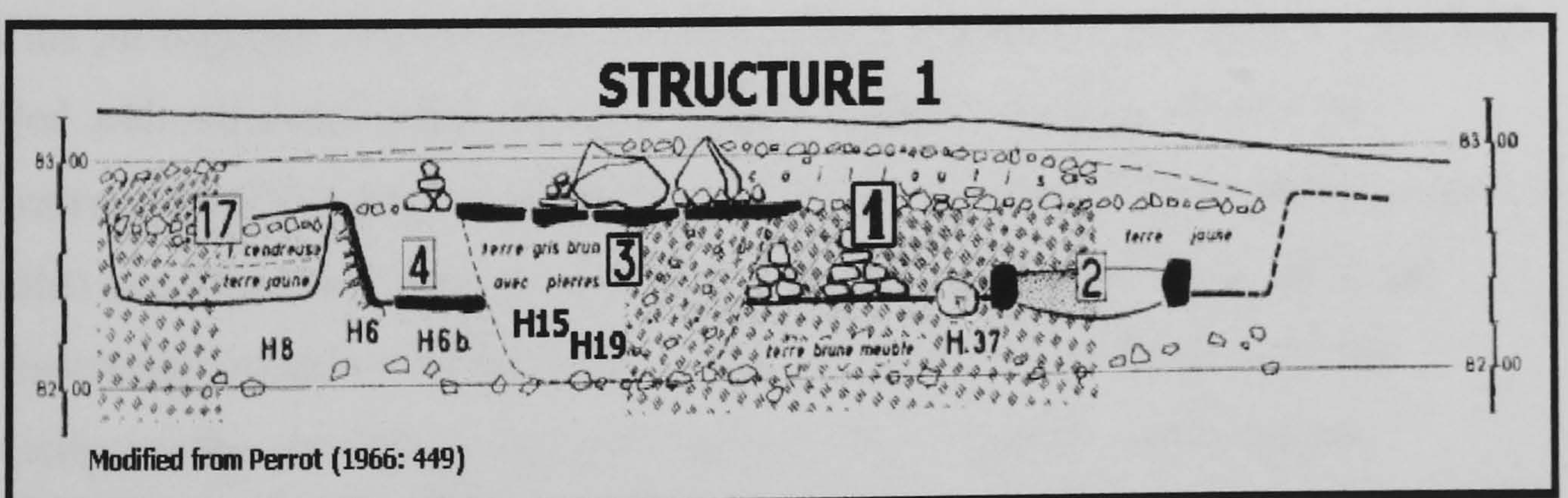


FIGURE 7.10 – Stratigraphical view of Structure 1 and the burial pit containing H15 and H19. The pit was placed inside the structure after it was abandoned, and it appears to have been closed with an elaborate construction including paving stones from the floor of the structure and piles of stones. The construction of the pit penetrated the floor of Structure 1 and disturbed eight of the burials that were located below the structure. (Modified from Perrot, 1966)

Burial pit 3 (Figures 7.09 and 7.10) was placed inside structure 1 after it was abandoned. It contained two individuals (H15 and H19), but according to Wright (1978) H15 was placed in the pit first and H19 was added later. This would indicate that these two individuals may have occupied the same pit, but they represent two separate single primary inhumation events. The construction of pit 3 disturbed the 7 burials (H16-H18 and H20-H23) that are shown in Figure 7.09, and the disturbed bones were interred with H15 and H19 (Perrot, 1966). Both individuals were placed on their back with a similar orientation, but their limbs were arranged differently (Wright, 1978).

H19 in burial pit 3 is one of only nine individuals at Mallaha that can definitely be associated with bead adornments. Perrot (1966: 461) describes the beads found on the cranium of this individual as a *dentalium headpiece*. The fact that H19 was adorned with beads and was placed in an apparently elaborate grave may be significant, but it cannot be used to argue for a pattern of socially symbolic behaviour. This co-occurrence of beads and elaborated grave is a unique event in the data on Natufian burials (Byrd and Monahan, 1995), and unique events cannot be used to establish patterns. Also, the fact that H15 shares the elaborate grave but was not adorned with beads can be used to refute the significance of this unique co-occurrence in H19.

The fact that burial pit 3 appears to be elaborately constructed may be an accident of its location. Figure 7.09 shows a stratigraphical diagram of structure 1 and the location of pit 3 containing burials H15 and H19. Perrot's (1966) description of the pit suggests that structure 1 had been long abandoned and almost completely filled with sediments when pit 3 was placed inside it. He suggests that the construction of the pit pierced the floor of structure 1 disturbing its paving stones. It is also suggested that these paving stones were incorporated into an elaborate construction on top of the pit when it was closed. Based on Perrot's (1966) description the elaborate nature of this grave may be nothing more than a serendipitous placement of a grave in a location that provided a quantity of stones and slabs that had to be disposed of too.

At present no substantial evidence exists at Mallaha for the deferential treatment of burials, but a considerable amount of evidence supports the opposite view. For example, if a previous burial is disturbed during a later burial the disturbed bones are simply placed in the pit with the new burial, which is exactly what happened with the bones from the seven burials that were disturbed during the construction of burial Pit 3 for the burial of H19 and H15. This indicates that neither the older burials nor the new burial has special significance, and that both are most likely an act of disposal. Also, some burials seem to have been placed in expedient locations such as the disused storage pits of abandoned structures or the deposits filling these structures. Several burials display aspects that indicate that they were being 'disposed of' rather than 'deferentially interred'. For example, the sediments of burials contain waste products such as broken tools, lithic debitage, and the ash from hearths instead of the sediments that were excavated from the pit (Perrot, 1989: 289). This demonstrates that the paradigmatic methodology of interpreting the data from the perspective of high-level concepts such as "deferential treatment" can easily lead to biased conclusions that cannot be supported by an analysis of the information that is contained in the data.

The presence of beads as an aspect of a burial is not sufficient to demonstrate that a burial is symbolically or ritually endowed. There must be some information that can be used to suggest that the presence of the beads is not a simple matter of an individual being buried with what ever they were wearing at the time of their death. This means that the presence of beads only becomes significant when it can be correlated with some patterned aspect of behaviour.

7.5.05 Grave Goods At Mallaha

Some authors have made much of the inclusion of groundstone fragments in the burials. A closer look at the evidence suggests that these are probably incidental inclusions. First, the practice is not 'typical' of Natufian burials or the burials at Mallaha specifically. A review of the data shows that fragments of groundstone artefacts can be found in many contexts (the fill behind walls, the building materials of walls, the building materials of hearths and postholes, and also mixed into the fill of trash pits and abandoned structures). In view of this data, it would seem surprising if we did not find fragments in the fill of some graves, but it does not confer any special significance to burials unless we are ready to confer the same significance to walls, hearths, postholes, and trash pits. Another aspect of the burials at Mallaha that has been conferred with special significance is the presence of stones over the joints of some of the individuals. Again, a review of the evidence will show that the presence of stones of many descriptions can be found in almost any context at Mallaha. Also, a body placed in a flexed position and covered with deposits that contain stones would inevitably result in some of the stones coming to rest near the head or joints.

7.5.06 Information Flow And Burials

Burials become a significant and important source of data in the Natufian, especially compared to pre-Natufian sites that almost never contain burials. The mortuary practices at Mallaha display some consistent features:

- many (if not all) of the dead were buried
- burials are virtually always flexed to some degree (Valla, 1981)
- burials in undisturbed contexts are almost always primary inhumations of a single individual
- the locations of individual burials are almost never marked
- burials are equivalent (i.e. those individuals that clearly contain ornaments or possibly grave goods are buried in the same locations and in the same manner as those that don't)
- disturbed bones from previous burials are simply added to the pit of the current burial
- burials are typically placed away from occupied structures (Perrot, 1989; Valla, 1990) [this is contrary to some earlier statements (Perrot, 1966 and Valla, 1981)]

These consistencies indicate that only three aspects of burials appear to have been constrained. First, a significant number of the dead at Mallaha were disposed of by employing the practice of burial. Second, there was a distinct separation of burial locations and occupation locations at the site. Third, they were buried within the bounds of the area that we recognise as the 'site'. A fourth possible aspect of burials that indicate that they may have been constrained in some way is the fact that some of the burials at Mallaha appear to have been grouped together even though the evidence indicates that they were not buried as a part of a group interment. These consistent features of the burials at Mallaha suggest that this behaviour was constrained, but whether burials were constrained by social organisation or by functional considerations is not known.

The burials at Mallaha also display some variable features:

- they do not display any consistent orientation (the orientation of the grave to the world appears to vary randomly)
- the orientation of the dead within the grave also varies (face up, left side, right side...)
- a very few of the burials contain ornaments
- one of the graves may have been marked
- a very few of the graves may have been constructed
- one individual (an infant) may have been interred under the floor of an occupied structure at Mallaha
- some burials were placed inside the fill of abandoned structures
- some burials were placed away from any structures, even the unoccupied ones
- some burials appear to have been the primary use of a pit
- some burials were placed in pits that had been previously used for other purposes

The highly variable nature of burials at Mallaha is indicative of behaviour that is part of the personal domain. In other words, many aspects of the burials at Mallaha were apparently not structured or constrained by social knowledge/behaviour, and they could vary freely. Even the aspects of these burials that do seem to be constrained may have environmental/functional explanations that cannot be ruled out at this time. On the other hand the burials were placed in locations that afforded information access to all of the occupants of the site. At this level of analysis the burials at Mallaha reinforce the view that social organisation in the Natufian was homogeneous and undifferentiated.

This analysis is restricted because the published data on Natufian burials is very limited. For example, Figure 7.11 is a table that contains the published data on burial orientation and bead adornment. Figure 7.11 presents data on 20 of the 105 burials from Mallaha. This data has been reconstructed from a half dozen sources. Fifteen of the burials have data about their degree of flex, and they are either flexed (7) or semi-flexed (8). Fourteen of the burials have data indicating their placement in the grave, and they are placed on their right side (6), left side (6), or their back (2). Fifteen of the burials have data about the orientation of the grave, and graves were oriented with the individual's head placed to the North (5), the South (5), and the East (5). This data indicates that there is no correlation between the presence of bead adornment and degree of flex, placement of body, or orientation of the grave. All aspects of the Natufian burials at Mallaha display no discernable pattern (except

Burial	Semi	Full	Left	Right	Back	North	South	East	Beads
6a	nd	nd	nd	nd	nd	nd	nd	nd	25
6b	nd	nd	nd	nd	nd	nd	nd	nd	10
15	1				1	1		?	0
19	1				1	1		?	25
23	nd	nd	nd	nd	nd	nd	nd	nd	8
43	1		1				1		70
66		1		1				1	0
80	1			1		1			0
81	1		nd	nd	nd	nd	nd	nd	0
82	1		nd	nd	nd	nd	nd	nd	0
87		1	1				1		35
88	?	1	1					1	75
89	1		1					1	25
90		1	1				1		0
91	1			1				1	45
92	nd	nd	nd	nd	nd	1			0
97		1		1			1		0
98		1		1			?	1	0
104		1		1		1			0
105	nd	nd	1				1		0

FIGURE 7.11 – Natufian burials from Mallaha that have published data on degree of flex, position of body, orientation of grave, and association with beads.

those aspects that may be explained by functional mechanisms). This indicates that they are not part of a socially constrained symbolic system. All claims to the contrary are conjectural, and they cannot be demonstrated by the available data.

The burial data that has been published for Mallaha is rather fragmentary, but my analysis is consistent with the general descriptions of the burials that are provided by the excavators. This means that there is very little chance that a more complete data set would alter the analysis in any substantial way. The burial analysis is comparable to the architectural analysis presented above, and it also demonstrates the distinctions between interpretations based on paradigms and interpretations based on theories that were discussed. This analysis of burials and architecture represents two facets of an integrated whole, which is only possible with the theory methodology.

It is possible that a researcher could arbitrarily constrain the interpretation of several aspects archaeological data to be analysed from a comparable perspective within the paradigm methodology. The distinction is that within the paradigm methodology it would be the researcher that constrained the analysis and not the paradigm. Within the context of an interpretation that is based on a theory methodology it is the theory that constrains the analysis, not the researcher.

7.6 BEADS AND ORNAMENTATION

The data on beads and other forms of ornamentation at Mallaha is very limited and cursory. This may be due to the difficulty involved in interpreting ornamentation. Without a theory or paradigm that provides a context for interpreting ornamentation very little effort is invested in processing and publishing the data.

7.6.01 The Use Of Beads

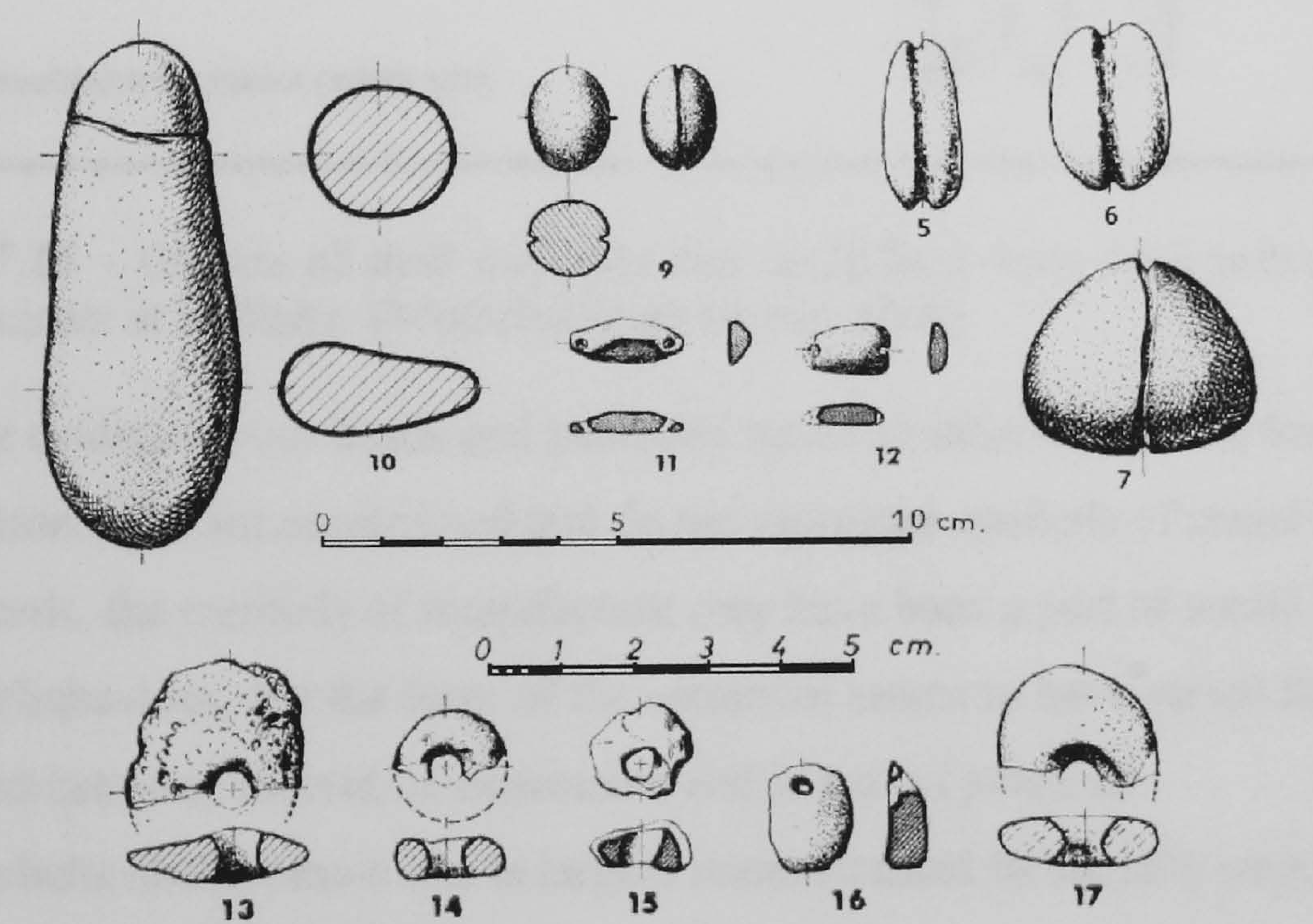
The use of beads at Mallaha suggests a pattern of behaviour that is distinctly different from that associated with the structures at the site. Unlike architecture, beads display no consistent attributes beyond the fact that they are found everywhere on the site. Beads at Mallaha display the following variable features:

- beads are made of many types of raw material (shell, bone, tooth, and stone)
- some beads are used in their natural form and some are shaped from raw materials
- beads are manufactured using a number of highly variable techniques
- beads were apparently worn on many parts of the body (head, neck, arms, legs, torso...)
- beads are evident in abundant quantities, but only nine burials can be definitely associated with them at Mallaha

If the use of beads was constrained by cultural processes then the evidence from Mallaha does not indicate this condition. For example, beads can only be directly associated with nine burials at Mallaha. Eight of these burials are indistinguishable from virtually every other burial at Mallaha (in other words, those individuals that were buried with bead ornaments are buried in the same locations and in the same manner as those that were not, therefore, the presence of beads does not indicate any preferential treatment of that individual). The "unique bead burial" is distinct from the other bead burials because it is an infant, and it is the only burial at Mallaha that may have been interred through the floor of an occupied structure at this site.

Beads are not associated in any way with a pattern of special treatment of structures, space, or individuals. In other words, bead use at Mallaha displays features that would most likely be considered to be personal expression, which is part of the individual's personal domain of knowledge and behaviour. At present it is not possible to establish any socially patterned or organised use of beads at Mallaha, but this may be partially due to a lack of in-depth data collection or analysis. The evidence from bead use at Mallaha tends to support the view of homogeneous information flow, and it certainly cannot be used to refute it.

Figure 7.12 displays a number of basalt items that appear to have been used as ornaments. Items 5-7, 9, and 10 may have had mundane functional uses (such as net weights, loom weights, or bola weights), but they could have been forms of beads or pendants. Items 11 and 12 are almost certainly beads that are double drilled to allow them to be strung in place instead of dangling as pendants. Item 16 is obviously a pendant, and items 13-15 and 17 represent a range of size, style, and quality in basalt drilled beads. These are all examples of beads and pendants that were formed from a raw material that began with a completely different shape and look than the finished item.



Modified from Perrot (1966: 472 and 473)

FIGURE 7.12 – Examples of stone objects that could have been used as beads or pendants at Mallaha. (Modified from Perrot, 1966)

Figure 7.13 presents examples of beads and pendants from bone and shell. Some of these maintain their natural shape with only a slight alteration to provide a means for use as a bead or pendant (Figure 7.13: 1 and 3-7). Many of these are shell and bone that are produced using a number of techniques to produce a bead or pendant from the raw material. For example, bone may have been cut, shaved, abraded, drilled and incised to produce a bead or pendant that has little resemblance to its original form (Figure 7.13: 11-14 and 16). Other items may retain some of their distinctive aspects (Figure 7.13: 21).

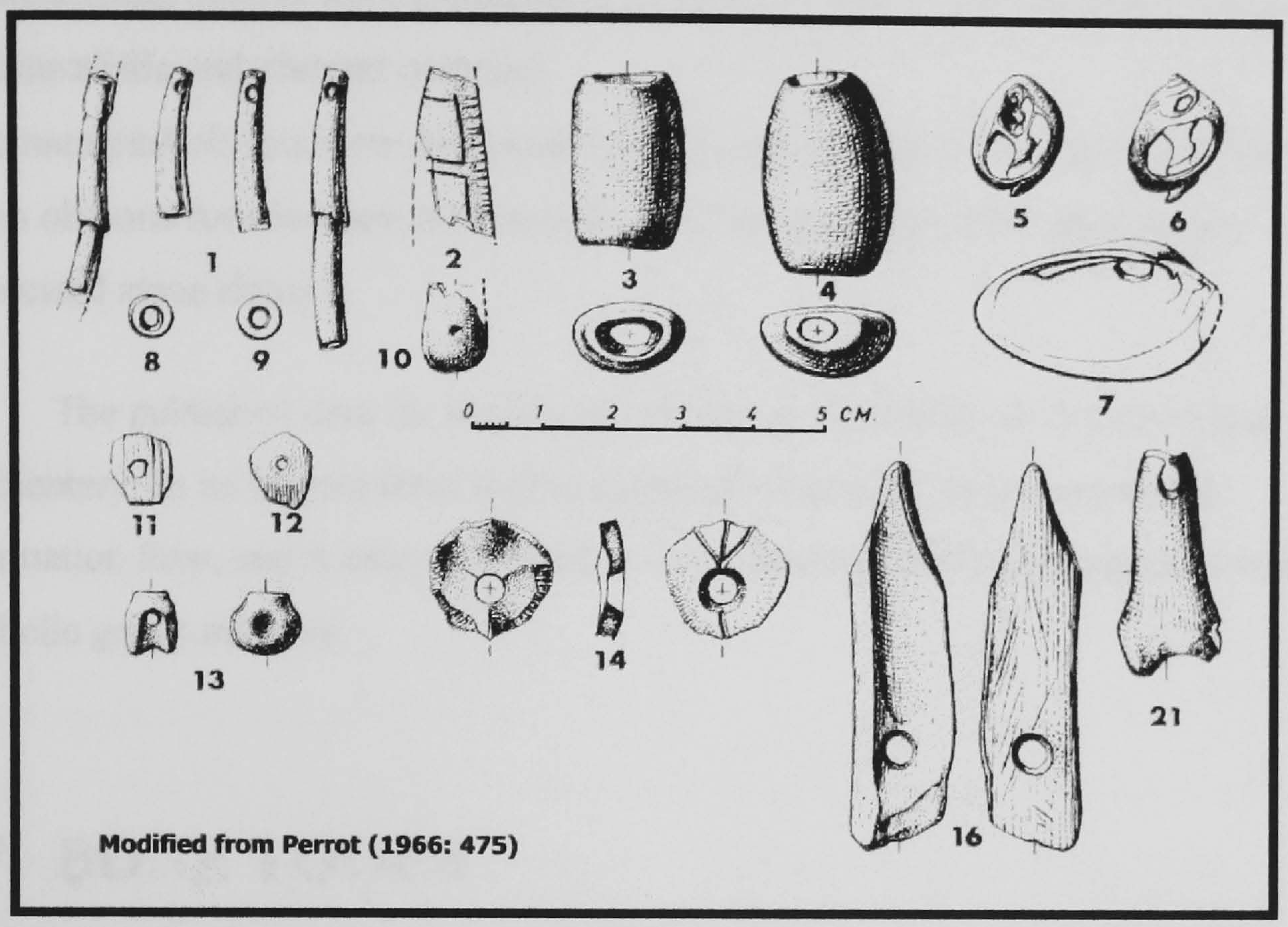


FIGURE 7.13 – Objects of shell and bone that could have been used as beads or pendants at Mallaha. (Modified from Perrot, 1966)

The evidence from beads and pendants seems to indicate that the forms of ornamentation were not constrained and do not represent symbols of social identity. In other words, the methods of manufacture may have been a part of social group knowledge/behaviour, but the form of the ornament seems to have varied freely, which is indicative of individual expression and is part of personal knowledge/behaviour domain that is largely unconstrained by socially imposed forms, such as group identity markers.

7.6.02 Ornamental Items At Mallaha

The ornamental items at Mallaha seem to display no consistent features. Their varying features include:

- some were formed from natural objects and only minimally altering their original appearance (bones, shells, seeds, teeth…)

- some items were shaped into objects that do not resemble the original shape or texture of the raw material used (bone, shells, stone...)
- ornamental objects were produced using a number of methods [carving, grinding, drilling, incising, polishing, shaving...]
- ornamental objects were produced in a variety of shapes and patterns [including naturalistic and abstract patterns]
- ornamental objects were produced on utilitarian objects as well as on objects with no obvious function beyond symbolic [such as personal ornamentation and incised stone slabs]

The published data for beads and ornaments from Mallaha is limited and fragmentary. In its current form it does demonstrate aspects of homogeneous information flow, and it cannot be used to demonstrate socially constrained use as symbolic group markers.

7.7 BONE TOOLS

There is no systematic treatment of bone tool data from the Natufian (Bar-Yosef, 1983). This can be demonstrated by comparing two lists of bone tools from Mallaha – one produced by bar-Yosef (1983) and the other produced by Stordeur (1991).

Bar-Yosef (1983)	Stordeur (1991)
Burnisher	Common smoothing tools
Awl	Flared smoothing tools
Spatulae	Spatulas/spoons
Point with articulation	"Dagger"
Pierced point (needle with eye)	Retouching tools
Elongated point	Composite tools
Fully shaped point	Points
Bi-point	Bi-Points
Sickle haft	Handles/hafts
Pendant (phalange)	Pendants
Pendant (shaft)	Chisel
Pierced bone	Flat knives
Various bone objects	

Either list presents a picture of an impressive bone technology, but the data is not presented formally or systematically. For example, no data on the context of any of the bone finds have been published for Mallaha. This leaves analysis to general statements such as the fact that bone tools are found in all contexts at Mallaha, and no apparent pattern of use or disposal is evident (Perrot, 1966).

A more systematic methodology may reveal previously undetected patterns of use or manufacture in the data for bone tools at Mallaha, but at this time the data represents a homogeneous information pattern that can only be interpreted as homogeneous information flow.

7.8 LITHIC TOOLS AT MALLAHA

7.8.01 Chipped Stone Industry

In the early 1970's D. O. Henry undertook an analysis of the Natufian complex from several sites. One of his general conclusions was that a wide variation of tool forms was produced from a remarkably homogeneous production tradition (Henry, 1989). Henry's analysis verified the view of the material from Mallaha that was produced by M.-C. Cauvin (1966). According to Cauvin, the lithic technology at Mallaha is nearly homogeneous across the excavated area, and displays the slight temporal variations that are typical for the Natufian lithic industry (Cauvin, M.-C., 1966). A third analysis, which focuses on the final Natufian at Mallaha, supports the work by M.-C. Cauvin (Valla *et al.*, 2001).

The work conducted by Valla *et al.* (2001) compared lithic assemblages from several contexts within the final Natufian layers at Mallaha. The lithics from inside of structures were compared to the lithics found outside of structures, and the lithics found in each structure were compared to the lithics from each of the other structures. The homogeneous nature of lithic production was once again confirmed. No differences in the production of flakes or blades could be demonstrated from context to context whether the contexts were located inside or outside of structures (Valla *et al.*, 2001). At least some of these contexts display indications of being primary deposits (Valla *et al.*, 2001). This indicates that the production of flakes and blades at Mallaha is contained within a homogeneous information flow.

This is very significant evidence for homogeneous information flow because lithic reduction produces a database that has excellent properties for analysing and demonstrating information flow. Lithic production at the level of blade production represents a complex set of procedures, and there are a number of possible ways of producing the desired results. The only thing that would keep the production sequence homogeneous is information flow. In other words, Natufian lithic production represents a complex system of behaviour, and each worker would diverge from the others in their production techniques if they were not constrained by the social structure of the group. This perspective can be examined through the example provided by Bradley and Stanford (2003).

Bradley and Stanford have suggested that there is a striking similarity between the Solutrean blades of the Upper Palaeolithic in Europe and the Clovis point of North America. They undertook an analysis of the production techniques involved in producing the Clovis point, the Solutrean blade, and a similar blade from an Asian complex. The purpose of this analysis was to determine if the production sequences of these three tools could reveal the origins of the Clovis complex (either Asian or European). Figure 7.14 presents the results of this analysis.

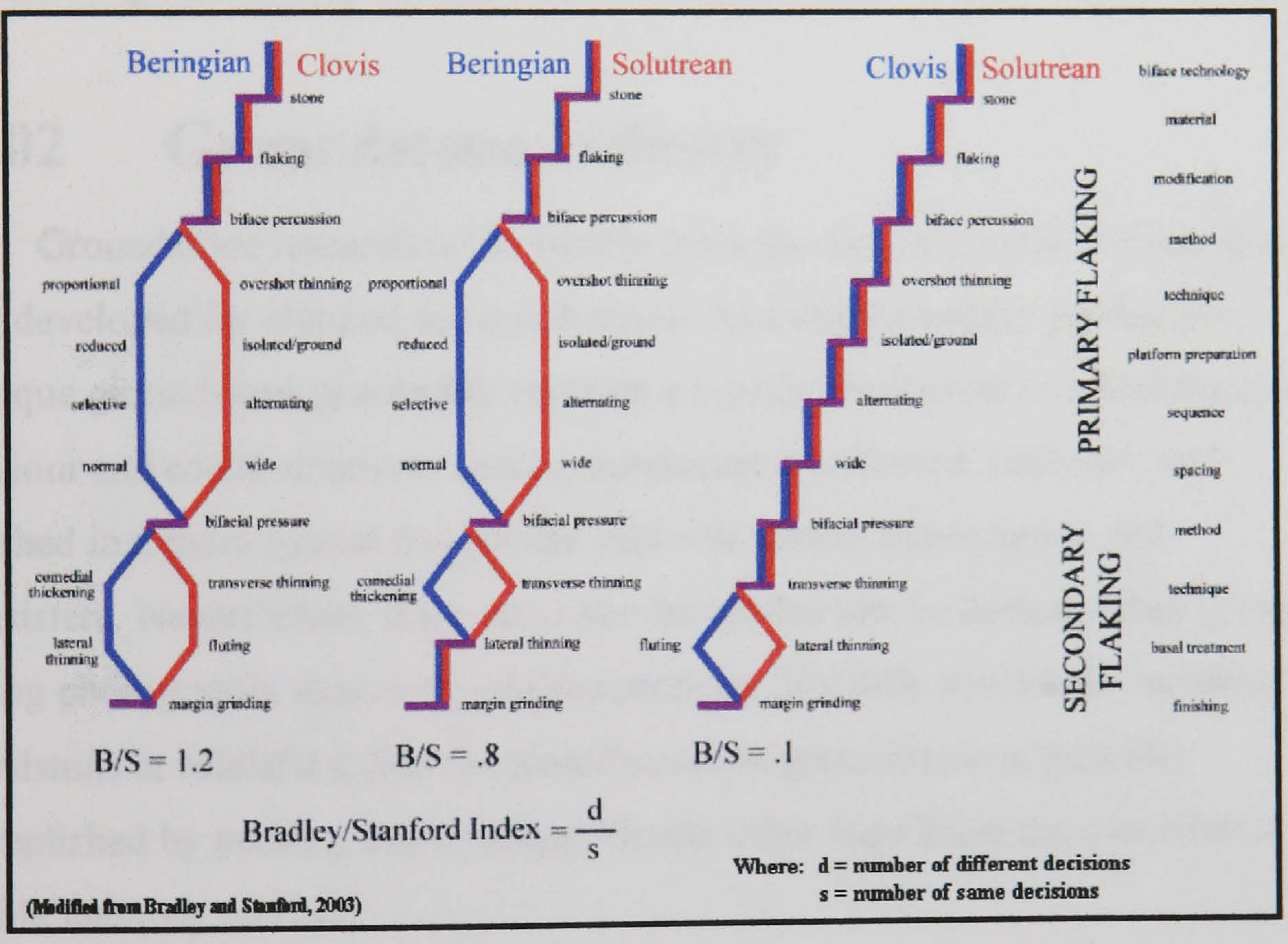


FIGURE 7.14 – Comparison of production sequences from Asian, Solutrean, and Clovis blades/points. (Modified from Bradley and Stanford, 2003)

Figure 7.14 represents a formal analysis of the decisions involved in a production sequence that results in very similar end items. The Bradley/Stanford Index (BSI) indicates the degree of difference for a comparison. If the BSI for a comparison is 0.0 then the production sequence for the two items is identical. The comparison of the Asian (Beringian) and Clovis tools produces a BSI of 1.2, the Asian and Solutrean comparison produces a BSI of 0.8, and the comparison of Clovis and Solutrean produces a BSI of 0.1. This indicates that the Clovis and Solutrean production sequences are nearly identical, and that they both diverge dramatically from the Asian production sequence. CSTC explains this pattern as an example of cultural entities that have a deep similarity due to shared information (Solutrean and Clovis) contrasted by cultural entities that have a superficial similarity due to the convergence of complex systems (Asian/Clovis and Asian/Solutrean). In other words, the Clovis is best explained as a cultural entity that has its origins in the Solutrean of Europe and not in the Asian blade industry.

The methodology employed by Bradley and Stanford is an example of the type of methodology that CSTC demonstrates to be effective at reconstructing the social organisation of past cultures through the inferred flow of information that is evident in the material products of complex behaviours. Lithic production can be a highly complex and highly structured source of information, which is ideal for demonstrating information content and inferring information flow in past cultures.

7.8.02 Groundstone Industry

Groundstone research could benefit from the type of formal analysis that is being developed for chipped stone industries. As a fairly complex production technique groundstone potentially contains a significant amount of information about behaviour and social structure. Until groundstone is collected, analysed, and published in a more formal manner the data will remain rather sparse and inconsistent. Nevertheless, there are a few things that can be demonstrated using the existing photographs, drawings, and descriptions. The only consistent feature of the groundstone at Mallaha is that the manufacture of groundstone is typically accomplished by pecking and grinding. On the other hand there are a number of variable features, such as:

- groundstone may be decorated or not
- groundstone is constructed of various types of lithic material
- groundstone may have a number of functional purposes
- groundstone is executed in a variety of shapes and sizes (even for similar or identical uses)
- groundstone may be used or stored any where on the site

- groundstone may be disposed of in a number of ways (using broken or depleted groundstone to build walls, to build hearths, to wedge posts into post holes, or as part of the fill behind walls, in pits, or in abandoned structures)

Some of this large range of variation may be due to functional considerations, but much of it is probably due to individual expression and the fact that groundstone construction and use is not constrained by any discernable social structure.

There are several important questions that can be addressed by an analysis of the groundstone at Mallaha. First, what is the functional repertoire that is represented by the groundstone? Second, Does the pattern of use and disposal indicate 'special' treatment of groundstone? Third, does the shape, quality of craftsmanship, or decorations of the groundstone indicate a pattern of differential use or access to groundstone?

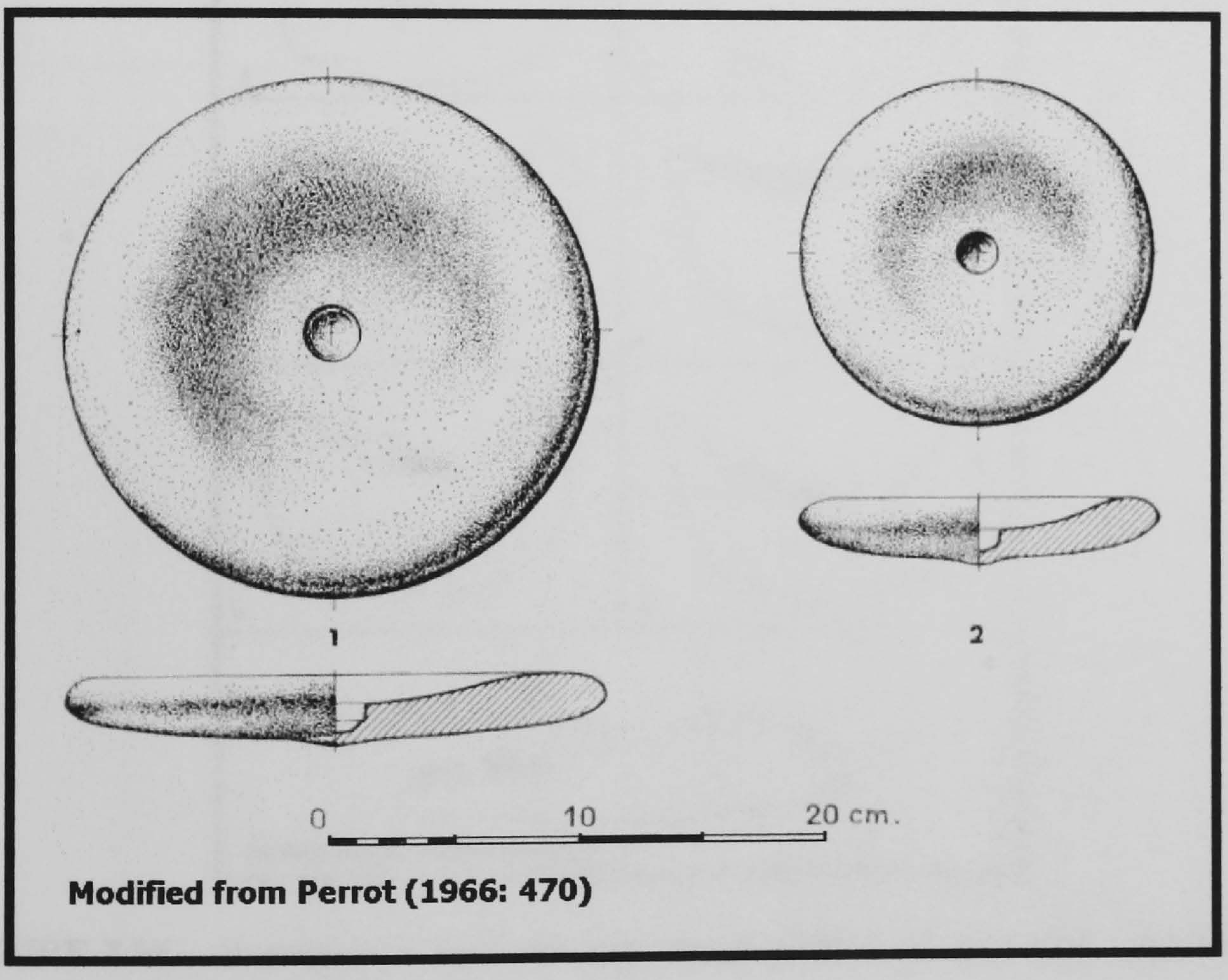


FIGURE 7.15 – Groundstone artefacts from Mallaha that may be examples of "lamps". (Modified from Perrot, 1966)

The groundstone at Mallaha has a number of uses. It can be simple handstones for polishing or abrading, or more elaborate mortars and pestles for pounding and grinding. Groundstone is also used as items of adornment and possibly the Southern Levant's first known instance of a simple form of lamp. This last example is one of my observations, which I will briefly discuss. Figure 7.15 shows two of the best-preserved examples of the form that I suggest is a 'lamp'. Beaune (1987) discusses the form and use of "fat lamps", and the examples in Figure 7.15 are similar in appearance to some of her examples (Figures 7.16 and 7.17), and they are functionally adequate to be employed for this use. Briefly, a piece of animal fat is placed near the outer rim and a small piece of fat is placed in the central depression. When the central piece is lit the flame melts fat from the larger source at the rim and the liquefied fat runs down into the centre and feeds the flame. These forms from Mallaha are identified as "unknown", and they have not been subjected to residue analysis. If these are "fat lamps" then the uses of groundstone in the Natufian has become very broad indeed.

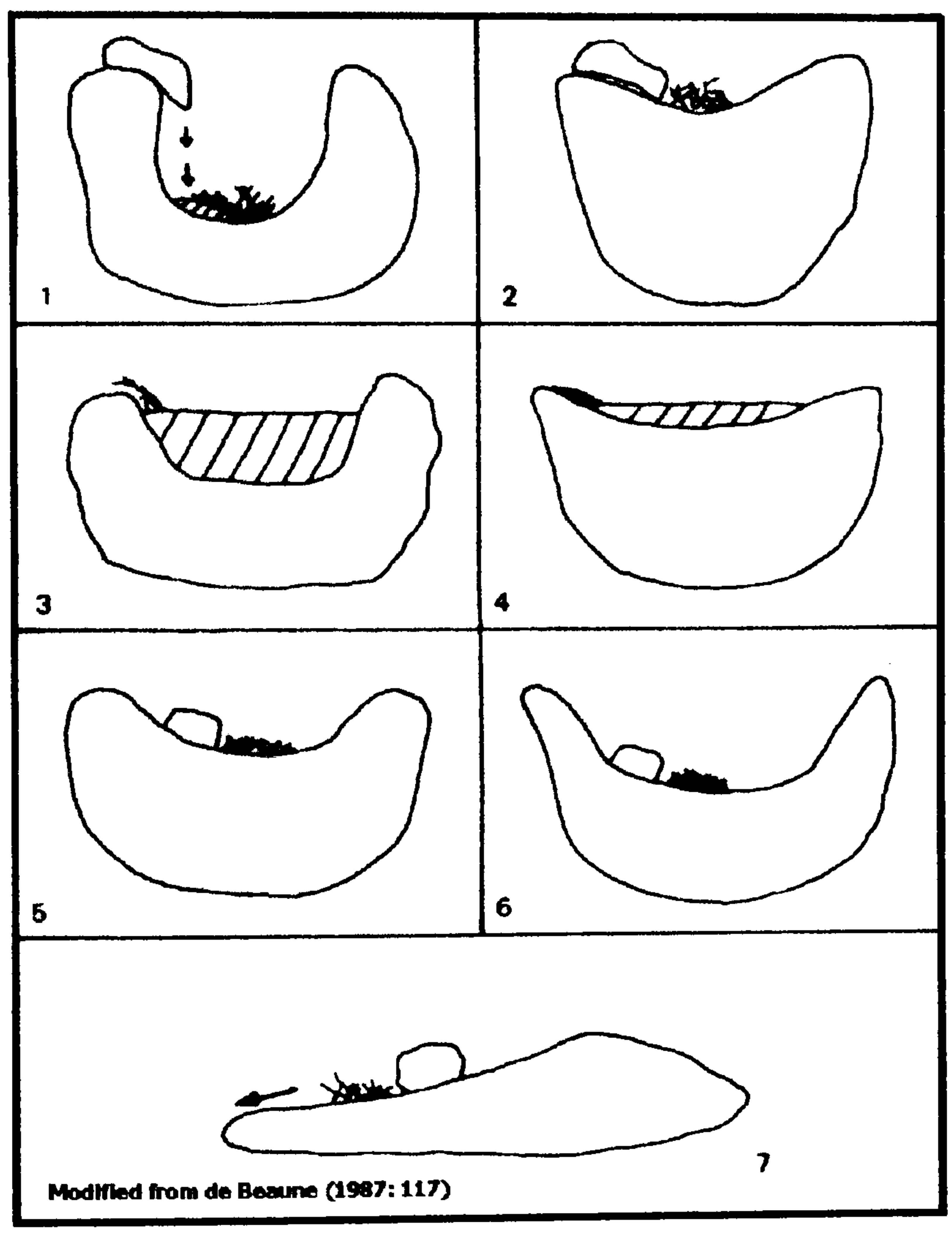


FIGURE 7.16 – Examples of the functional characteristics of 'fat lamps'. (Modified from de Beaune, 1987)

Some of the prominent aspects of certain classes of groundstone may be correlated with functional parameters. Figure 7.18 shows the rim profiles of items that could be characterised as bowls or mortars. There is a considerable amount of variation of the angle of the sides ranging from about 45 degrees off vertical (Figure 7.18: 6) to vertical (Figure 7.18: 9, 10, and 13). Also the edge can range from nearly pointed (Figure 7.18: 4, and 6-8), to rounded (Figure 7.18: 3, 5, and 13), or blunt

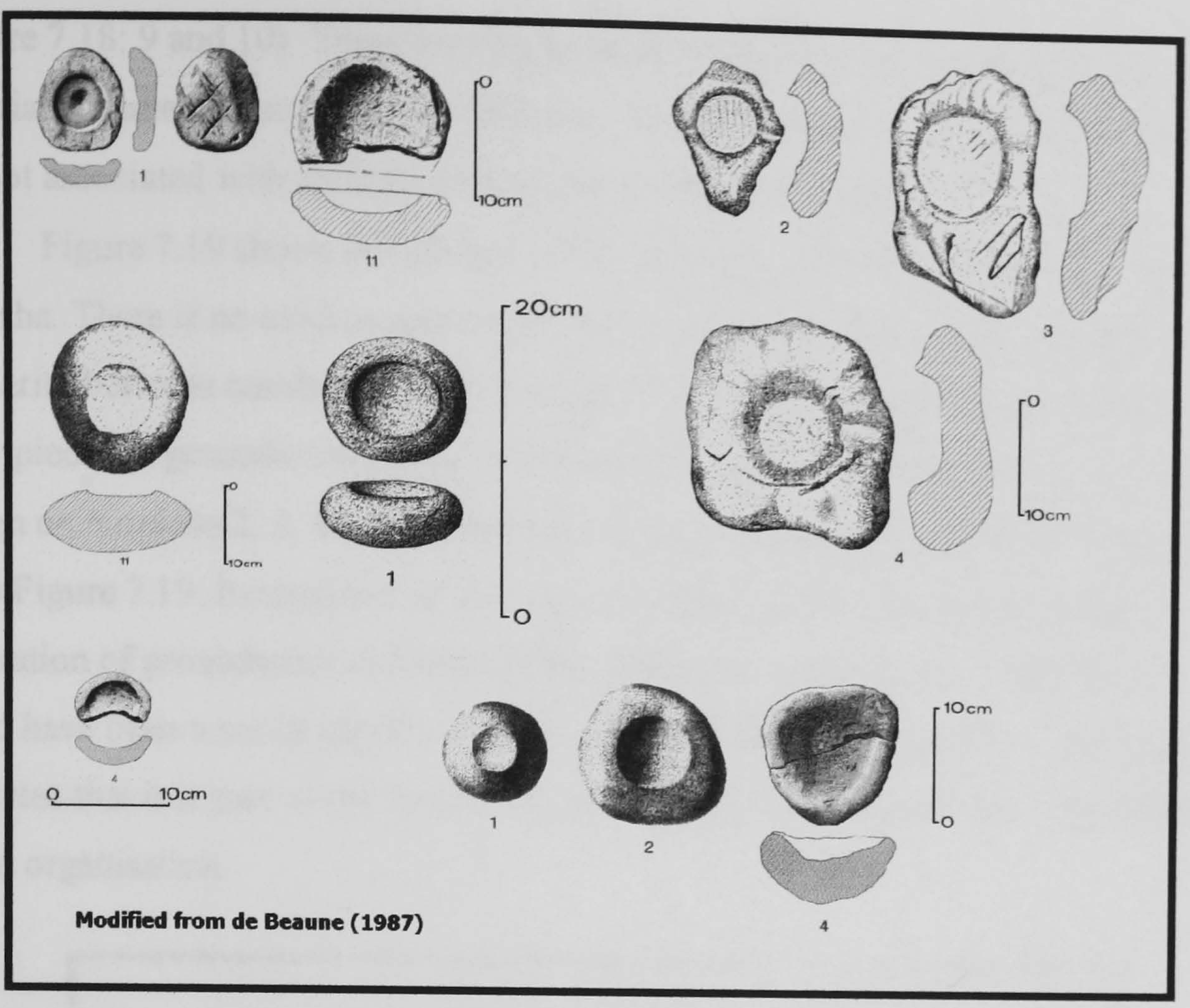


FIGURE 7.17 – Examples of the variation in size and shape of 'fat lamps'. (Modified from de Beaune, 1987)

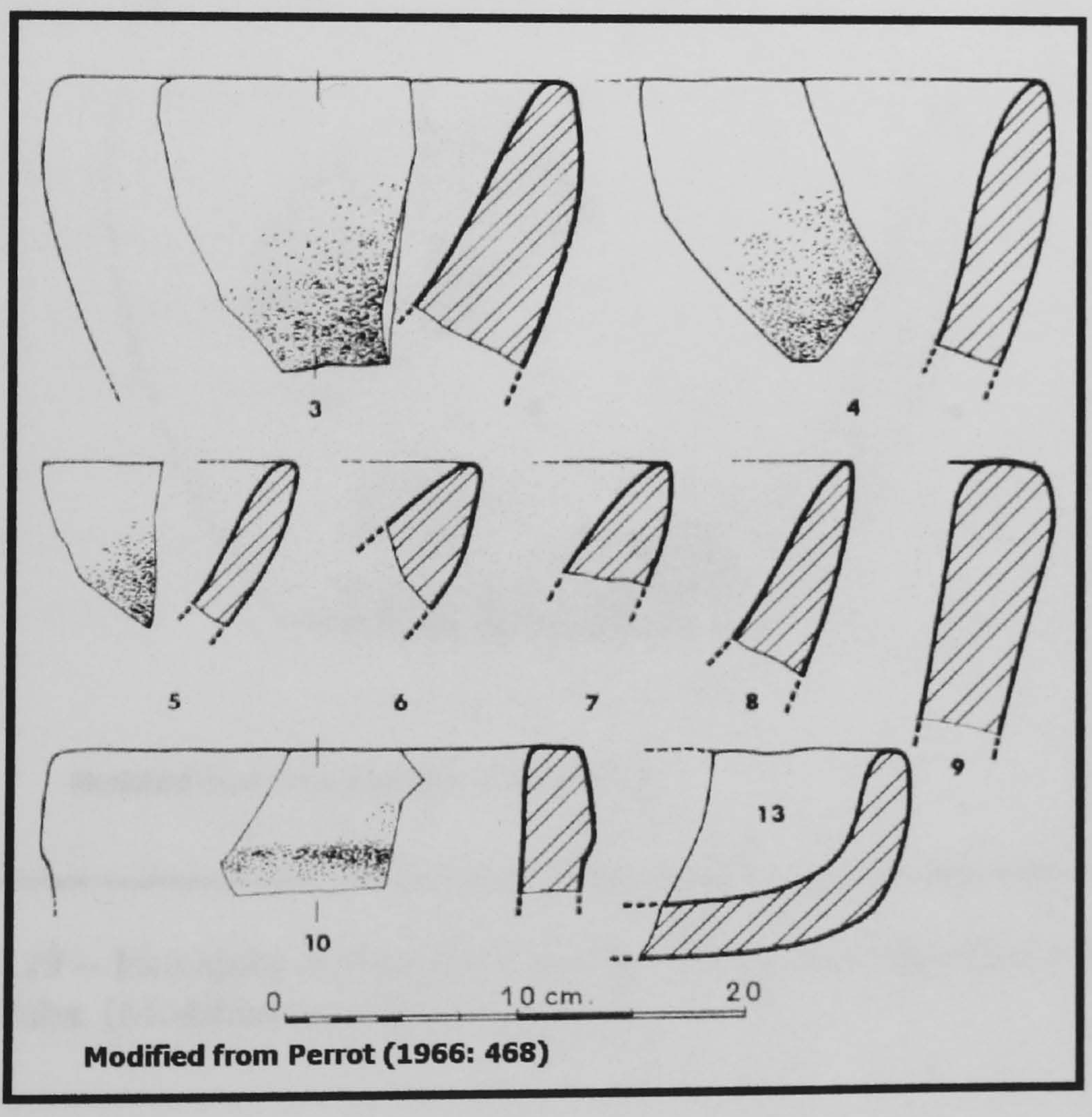
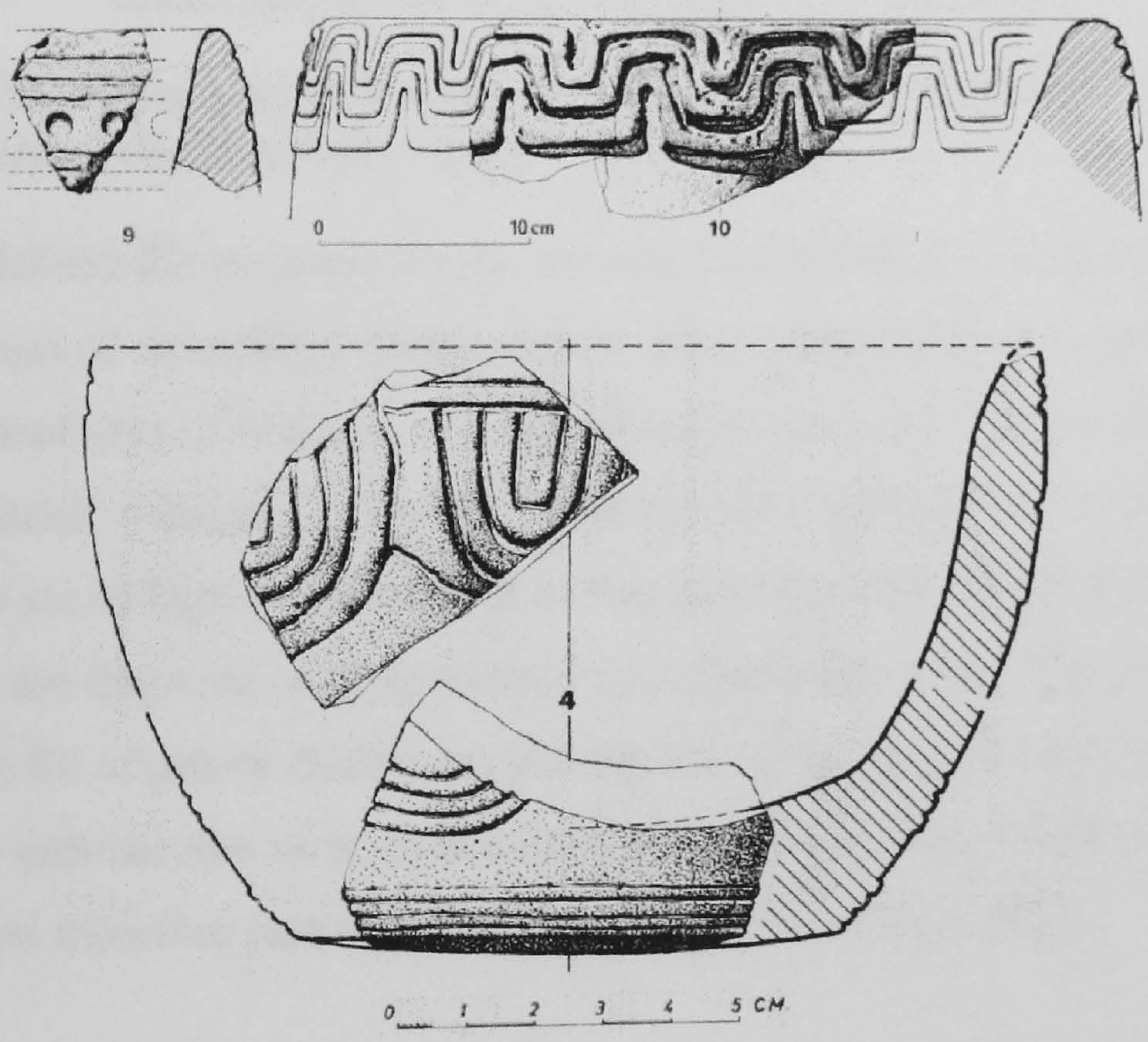


FIGURE 7.18 – A range of rim profiles that can be found on the groundstone at Mallaha. (Modified from Perrot, 1966)

(Figure 7.18: 9 and 10). These varying aspects are probably associated with raw material parameters (such as size) and use parameters (such as length of time used), but not associated with socially constrained concepts of design.

Figure 7.19 shows the designs on the three decorated bowls/mortars from Mallaha. There is no evident pattern although some researchers might suggest a similarity between numbers 4 and 10. Figure 7.20 displays the designs found on other pieces of groundstone, and it is evident that there is a general similarity of design on numbers 2, 3, 16, and possibly 14 that is comparable to that of items 4 and 10 in Figure 7.19. Irrespective of this vague similarity, there is nothing in the decoration of groundstone at Mallaha that can be put forward as a 'tradition' that could have been a social identity marker. The high degree of variability of designs indicates that it is part of the "personal" domain of knowledge and not constrained by social organisation.



Modified from Perrot (1966: 467 and 476)

FIGURE 7.19 – Examples of designs found on a few groundstone bowls/mortars at Mallaha. (Modified from Perrot, 1966)

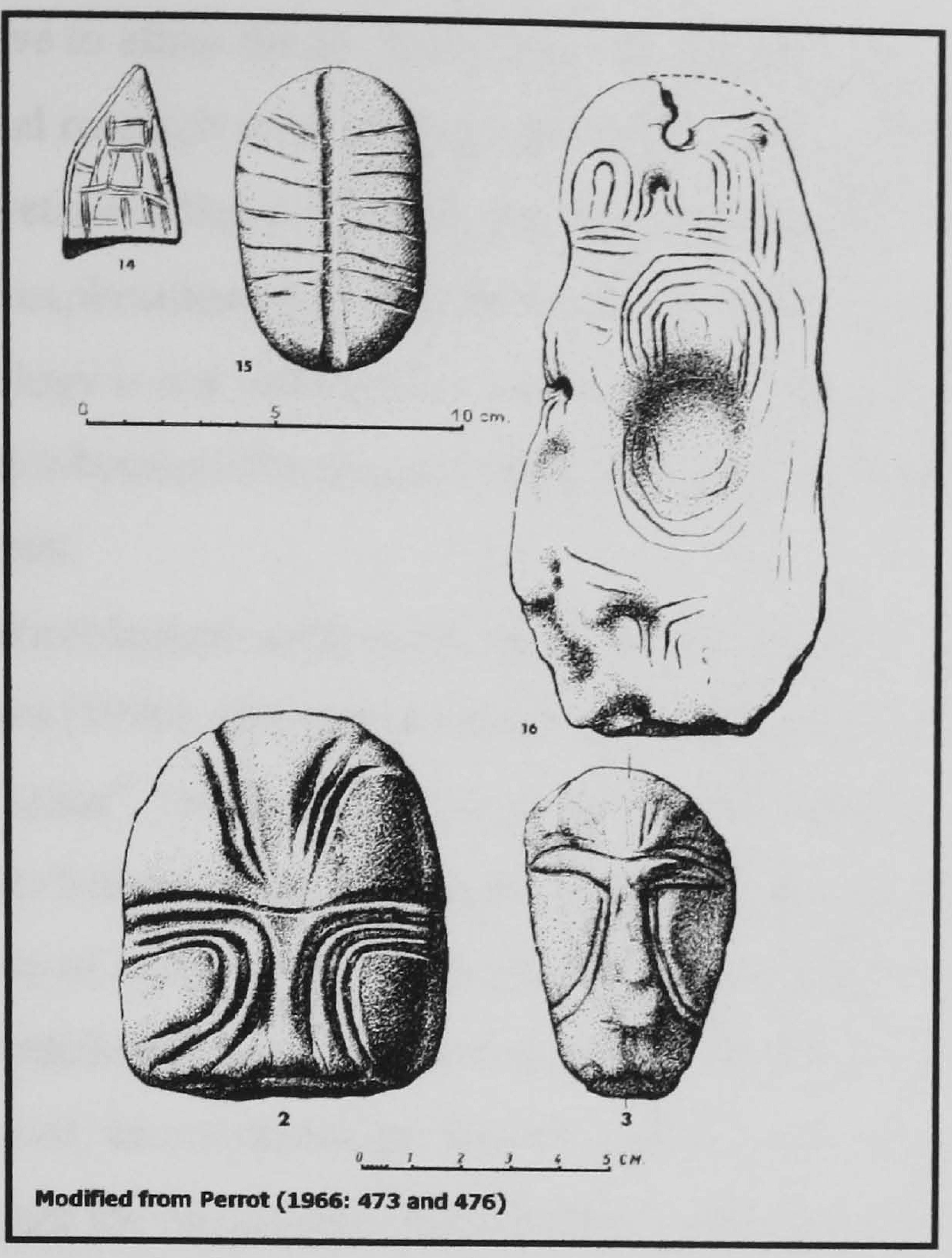


FIGURE 7.20 – Examples of designs found on a few miscellaneous objects at Mallaha. (Modified from Perrot, 1966)

At Mallaha the evidence for the use and disposal of groundstone indicates that it is all part of an undifferentiated whole. First, groundstone is found everywhere in the excavated area of Mallaha. Second, all types are found together so there is no apparent 'special' treatment of certain forms that we might think of as special because they are of high craftsmanship or they are decorated. Third, all forms of groundstone are disposed of in equivalent ways (built into walls, hearths postholes or as part of the fill of pits or structures). All aspects of the use and disposal of groundstone indicate that its form and decoration is under the control of the individual and therefore part of the "personal" domain of knowledge.

7.09 CONCLUSION

This chapter has two equivalent goals. First, this chapter attempts to demonstrate the difference between paradigmatic and theoretic methodologies. Paradigm based interpretation is typical of archaeological research, and theory based interpretation is the ideal to be achieved in the "hard" sciences. I contend that the application of a suitable theory in archaeological research will provide the means for archaeology to strive to attain the same ideals as the "hard" sciences, which will make archaeological research equivalent to any science. This should be evident in the fact that the interpretations that are based on a theory can be said to be scientific in that they represent explanations that are repeatable and testable. In contrast, a paradigm methodology is not sufficient to ensure that interpretations are either repeatable or testable because the interpretations are based on subjective high-level nebulous abstractions.

Typical archaeological interpretations are represented here by the example provided by Sanders (1990). His interpretations are based on high-level concepts such as "personal space", "territoriality", and "semiotics". No aspect of his interpretation is constrained by the paradigm he employs because paradigms are inherently incapable of constraining interpretation. Each aspect of interpretation within a paradigm methodology is a matter of subjective choice on the part of the researcher. In contrast, an interpretation that is based on a theory methodology is constrained to engage the mechanism that the theory puts forward to explain the phenomenon that is the focus of the interpretation. Any researcher that does not engage the explanatory mechanism of the theory has automatically reverted to a paradigm methodology.

CSTC explains cultural phenomenon from the perspective of information, and CSTC explains the patterned aspects of culture in terms of the flow of information (as self-organising features of a complex system). Archaeologists have been extracting and interpreting information from the archaeological record for centuries, which provides a working methodology for dealing with information contained in material culture. CSTC would benefit greatly (as would all of archaeological research) from a formal methodology for dealing with information, but one has not yet been developed. This has two implications, first CSTC is just as effective at handling information as any other archaeological methodology, and second, CSTC explains cultural phenomenon as a function of information. This focus on information in a theory could provide the insight and incentive to develop a formal methodology for collecting, analysing, and interpreting the information content in all aspects of archaeological data.

I have presented a theory that deals with cultures from an information perspective that is based on Dynamical Systems Theory. As such cultures are self-organising information systems that are dependant on processes, not static structures, to give form to their observable mechanisms and products. This theoretical perspective allows the analysis of material data to infer and demonstrate the patterns of information flow and accumulation that produced them. Information flow and accumulation demonstrates aspects of social organisation and differences between social knowledge and personal knowledge.

An analysis of information flow and content at the Natufian site of Mallaha was presented in this chapter. The level of analysis was constrained to be relatively general and conceptual due to the nature of the data available and the degree to which this theory has been developed. With more detailed data and a more formalised version of this theory the level of analysis available should improve.

The result of this analysis demonstrates that all aspects of material evidence from Mallaha indicate a condition of homogeneous information flow that would be expected in an egalitarian social organisation. In other words, it indicates that all members of the site interacted freely with each other and information flowed freely and equivalently to all members of the occupation. This indicates a high level of inclusive group behaviour. None of the evidence displays indications of preferential access to information that would indicate a differentiated information flow that would be characteristic of a hierarchical social organisation or even a slightly complex organisation that would involve differential access to information through ownership of property or inherited position.

Mallaha is a relatively large site, and it may have been occupied by as many as 300 people at one time (Perrot, 1966). The analysis produced here demonstrates that the social structure at this site is equivalent to the social structure that is typically assumed for sites that were occupied by as little as 10 to 30 people. The fact that no social structure is evident at Mallaha can be explained in two ways. CSTC may not be able to identify social structure in the archaeological record. On the other hand, CSTC may be effective at identifying social structure in the archaeological record, but there is no structure at Mallaha to be identified. This issue will be addressed in the next chapter where part of the data that is examined will represent the PPNA and the PPNB. If CSTC can identify social structure in the archaeological record then the PPN should provide the necessary data.

CHAPTER 8

A DIACHRONIC COMPARISON AND ANALYSIS OF THE DATA FROM SIX SITES

CHAPTER 8

A DIACHRONIC COMPARISON AND ANALYSIS OF THE DATA FROM SIX SITES

Providing an explanation for the variation and change in human behaviour is the primary goal in Archaeology (as a social science) (Hill, 1977: 59). The problem is that the typical activities of an archaeologist involve describing the data, not providing an explanation of why the data displays the patterns it does. The typical activities that Hill (1977) lists (creating typologies, generating trait lists, demonstrating statistical correlations, and devising sequences) are all fundamentally descriptive endeavours, and the interpretations that result from such activities do not constitute explanations. Only interpretations that are produced within an explanatory context can be said to stand as explanations, and descriptive paradigms do not provide explanatory contexts.

Hill makes an astute observation with regard to explaining the variability that is encompassed within change and stability:

> "...change and stability...appear to be two sides of the coin in that the same general kinds of processes probably account for both (Argyris, 1959: 123; Buckly, 1968b)." (Hill, 1977: 60)

Hill could have made his statement even stronger because, as Dynamical Systems Theory (DST) demonstrates, the processes that account for change and stability are exactly the same. In CSTC (Complex-Systems Theory of Culture) change and stability are explained by a single mechanism (the flow and accumulation of information, which is essentially the process of learning). Implicit Learning Theory (ILT) explains how humans transmit information, and DST explains how this information transmission can self-organise into recognizable patterns of stability with distinct levels of variability. CSTC also explains how this process of self-organisation produces the accumulation of information that is responsible for quantitative and qualitative changes to occur within the system.

CSTC provides a theoretical basis for understanding the behaviour of complex cultural systems, and it can be used to explore and explain long-term changes in cultural phenomena. In other words, CSTC is a theory based methodology that can be used to generate explanations of cultural phenomena, to predict certain characteristics of cultural phenomena, and to generate testable hypotheses about cultural phenomena. The present chapter will exploit these attributes of CSTC in two ways. First, six sites (that represent approximately 30 ky) will be compared in order to discuss some long-term aspects of complex cultural systems. Second, burials and structures from the PPNA and the PPNB will be compared to the Natufian data discussed in chapter 7. The fundamental purpose of this comparison is to demonstrate that the inferred information flow that appears to be homogeneous in the Natufian is no longer homogeneous in the Pre-Pottery Neolithic. This demonstrates that the homogeneous information flow inferred for the Natufian site of Mallaha is not an artefact of CSTC, and CSTC is capable of demonstrating the presence of structured information flow when it exists in the data.

In Chapter 7 CSTC was used to explore and explain the data from the Natufian site of Mallaha – a relatively stable cultural entity. My research focuses on eras that typically encompass the Origin of Agriculture, so there is an implicit expectation that some form of explanation of change and especially the type of change that produces new or unique behaviour will be forth coming. One aspect of the present chapter is to demonstrate that CSTC does encompass such an explanation. In the present chapter the first section presents a diachronic comparison of information levels displayed at six sites.

One of the fundamental tenets of DST (Dynamical Systems Theory) is that systems near equilibrium will tend to react to perturbations, or external inputs, in a linear manner. This means that the magnitude of changes in the system will tend to be proportional to the magnitude of the input that causes the change. Also, the flow through systems near equilibrium will tend to be less efficient and constrained to a lower level than systems that are farther from equilibrium. In accordance with this, the accumulation of a portion of the flow in systems near equilibrium will tend to be less than that of systems that are farther from equilibrium. These attributes of systems near equilibrium have important implications for prehistoric societies, and will be the focus of the first section of this chapter – Diachronic Comparisons of Sites.

Two fundamental aspects of behaviour and knowledge have been omitted from these comparisons. I have simplified my comparisons by eliminating the two most difficult and problematic elements. First, subsistence is omitted because for most of these sites the direct evidence is either missing or extremely limited. Second, chipped stone activities are not included. Chipped stone technology is 2.5 to 3.0 my old, and it has become very complex from all of the elaborate techniques that can be employed to produce a tool. Chipped stone technology has also increased in complexity due to the increased number of activities that involve the use of or display of chipped stone artefacts. This complexity makes it difficult to integrate into the simple comparisons employed here, and as a category it does not seem to be comparable to the others employed in the comparisons. On the other hand, chipped stone technology should provide an excellent database for a possible future research project that could test the conclusions and hypotheses generated in the current research.

8.1 DIACHRONIC COMPARISONS OF SITES

CSTC can be used to explain both synchronic and diachronic patterns of self-organising information systems. Diachronic patterns of organisation are characterised by relatively long periods of stability that are interrupted by short periods of reorganisation. One of the reasons for this pattern is that periods of stability are required to maintain a coherent and self-organised structure within the system. Long periods of continuous transformation are referred to as “chaos”, which is inherently destructive to the coherent structure of a system. A stable system is characterised by an inherent level of variability and a level of quantitative change. A discussion of the level of variability of a stable system would involve a large number of parameters, which places it beyond the scope of this research. On the other hand, qualitative change within a stable system is fundamentally attributable to one aspect of the system, which means that it can be addressed at this time.

For systems that are near equilibrium, quantitative change will be very low, and qualitative transformations will be spaced very far apart. As a system moves away from equilibrium the quantitative change within the system will increase, and the qualitative transformations of the system will be spaced closer together. Qualitative transformations are inherently destructive to the structure of the system. For this reason a transformation will typically involve only one aspect of the system, but it will typically produce effects in the entire system.

A culture that is functioning within (or near) an equilibrium will tend to react linearly to perturbations. This means that, for the most part, changes in the behaviour of the system will be proportional in magnitude to the cause (i.e. small inputs will produce small changes and larger inputs will produce larger changes). Also, the relative amount of information that will be accumulated by a cultural system will tend to increase with the complexity of the system (i.e. systems close to equilibrium will accumulate information at a relatively low slow rate). For Example, nearly a million years elapsed between the advent of the first chipped stone technology and the first hand axe technology. Subsequent advances in chipped stone technology have occurred at an ever-increasing rate. This is often explained as a result of biological evolution, which implies that our ancestors were evolving more sophisticated brains with higher intelligence potentials. CSTC demonstrates that there is at least one alternative explanation, which does not require the process of biological evolution to explain the patterns of cultural change.

Systems near a state of equilibrium accumulate information at such a low rate that comparisons must be made over a vast time span, and this makes it difficult to suggest that the sites compared are really comparable. Nevertheless, that is what I am attempting to do in this section. I have selected six sites that represent the Upper Palaeolithic through the PPNB (a time span of roughly 30 ky). I am suggesting that these sites are in some respects comparable because they are:

1. relatively large (for their era),
2. relatively well preserved,
3. relatively extensively excavated, and
4. relatively well published.

This group of six sites represents my best efforts at locating sites that contain typical information levels for each era of this sequence of time. Each site is evaluated for eight categories of behaviour: architecture, beads, bone tools, burials, ground stone, hearths, ornaments, and pits. The Upper Palaeolithic site of Abu Noshra II provides the baseline condition for this discussion of information levels.

8.1.01 Information Levels Of The Six Sites

The archaeological record provides fundamental information about the behaviour of people of the past, and it is possible to infer the amount of information represented by the material residues of past behaviours. It is beyond the scope of this research to provide any measure of information levels at sites; therefore this discussion will be presented in very general and relative terms.

The first three sites to be discussed are Abu Noshra II, Ohalo II, and Neve David. These sites display relatively low levels of information with a small increase in information displayed from the Upper Palaeolithic through the Early and Middle Epipalaeolithic. For example, the Upper Palaeolithic site of Abu Noshra II contains a single relatively simple feature (a hearth that is ringed with stones), and some simple bone points (Phillips, 1990). The site of Ohalo II (which is later – at the boundary of the Upper Palaeolithic and the Epipalaeolithic) seems to indicate a slight increase in displayed information. There are indications of architecture (three brush huts), the presence of beads, and an incised bone ornament (Nadel et al., 1994; Nadel, Carmi, and Segal, 1995; Nadel and Werker, 1999). Huts and beads are evident at some Upper Palaeolithic sites so the actual increase in information displayed is very small. Neve David, a site from the middle of the Epipalaeolithic, displays a real but small increase in information content relative to the two earlier sites. For example, the architecture at Neve David incorporates the use of stones in the construction of its structure, and more sophisticated types of ground stone (mortars and bowls) are present (Kaufman and Ronen, 1987; Kaufman, 1989). Based on the data provided by these three sites (as typical representatives of their respective eras) the information accumulation evident in the sites from the Upper Palaeolithic through the middle of the Epipalaeolithic indicates a very low level of change.

In contrast to the previously discussed three sites, the Natufian site of Mallaha displays a dramatic increase in the level of information, and the subsequent PPN sites of Nativ Hagdud and ʻAin Ghazal display continuing increases of information accumulation. For example, Natufian architecture is constructed with large quantities of stone and it is dug into the underlying sediments, typically 50-100 cm. Beads are present in large quantities, and their configurations include headdresses, necklaces, armbands, leg bands, belts, and pendants (which forms are preserved in some of the burials). Bone tools include several new classes, including burnishers and chisels, and ground stone items are found in quite elaborate shapes, some of which are decorated with incised designs (Perrot, 1966 and 1989; Valla, 1991 and 1995).

The PPNA site of Netiv Hagdud displays some increases in information accumulation with respect to the Natufian. For example, structures incorporate a new building material (mud bricks) and the interior walls surfaces tend to be finished with clay or plaster, and burials typically display intentional skull removal for adults (Bar-Yosef, Gopher, and Goring-Morris, 1980; Bar-Yosef, Gopher, Tchernov, and Kislev, 1991). The PPNB site of Ain Ghazal displays a higher information content than any of the previous sites. For example, by the middle of the PPNB at Ain Ghazal the structures display a double wall construction, with the interiors of the walls finished with plaster that is frequently burnished and decorated with paint. Also, the structures display discrete plaster floors that are typically burnished and plastered. Another distinct increase in displayed information is evident in burials. The burials at Ain Ghazal are typically associated with structures, the skulls of adults are removed, and there is significant evidence that the skulls were plastered to recreate "faces" (Rollefson and Simmons, 1988; Rollefson, 1990a and 1990b).

The information level of sites before the Natufian is relatively low, and it increases at a relatively slow rate. The change of information level in the Natufian is dramatic and appears to be a rapid transformation. On the other hand the increases in information level at the PPN sites are relatively small compared to the dramatic change seen in the Natufian, but information increases in the PPN are larger than those evident before the Natufian. CSTC provides an explanation of this pattern. The pre-Natufian sites represent a stable system organisation that is near a condition of equilibrium. The Natufian represents a qualitative transformation of the system that resulted in a rapid change to the configuration of the system as a whole. This is seen in the elaboration of nearly all aspects of behaviour.

The Natufian increase in information is obviously the result of a transition that was caused by a dramatic and rapid reorganisation of behaviour. The dramatic increase in information level with the advent of the Natufian prompts an important question - "Was the reorganisation in the Natufian based on an elaboration of existing information or was it driven by new information?"

It is possible to demonstrate which of these two cases most likely characterises the conditions behind the Natufian transformation. The information level displayed at the Natufian site of Mallaha represents a reorganisation of behaviour. There is no new category of information displayed at Mallaha. The knowledge level at Mallaha is simply an elaboration of knowledge that is displayed at sites prior to the Natufian. The site of Mallaha represents significant increases in information levels that are associated with bone tools, ornaments, and ground stone. These are all existing categories of information, and the increases represent elaborations of existing forms. This demonstrates that the transformation evident in the Natufian occurred in an aspect of the system that is not evident in the direct material residue. The transformation could have been a change in one of the categories of information that does not leave direct evidence, such as social organisation, but the analysis of the data from Mallaha demonstrates that the Natufian maintains the same fundamental social organisation as previous cultural entities (see Chapter 7). An Aspect of information that is not contained in this discussion is the level of investment in sites. Once again this is a category of information that has too many parameters to address effectively in the present research, but a quick look at architecture and burial behaviour will provide some insight.

Pre-Natufian structures were relatively ephemeral, they were constructed using expedient methods and materials, and rarely were more than two structures evident on any site. During the Natufian at Mallaha as many as fifty structures may have been occupied at one time. Each structure represented a considerable investment of time and effort because they were dug into the sediments some 50 to 100 cm, and the walls were faced with a considerable quantity of stones. This represents a qualitative change in the behaviour associated with building structures at both the level of the individual structure and the site level.

When Natufian burials are examined they are not appreciably more elaborate than the burials from earlier cultural entities (which may include Middle Palaeolithic burials [Belfer-Cohen and Hovers, 1992: 468]). What makes the burials at Mallaha exceptional is that 105 have been revealed so far. At earlier sites it is rare to find even one burial. What this suggests is that the Natufian represents a dramatic change in the intensity of occupation of some sites, which is a perspective that is supported by the architectural data. It is not clear what this change actually represents, but it is clear that it is the fundamental basis of the elaboration of the categories of behaviour that have been discussed above.

Typically traditional explanations of cultural changes of this magnitude involve causes of an equal magnitude. On the other hand, DST demonstrates that complex systems frequently display emergent properties that are the result of very small variations. In other words, causes are often so small and operate over such long time-spans as to be undetectable. DST redirects our attention from questions such as "What caused the Natufian phenomenon?" to other questions, such as "What form did the Natufian phenomenon take?" The first question rarely has a meaningful answer beyond the fact that the Natufian phenomenon is an example of the characteristic behaviour of complex systems. We should not expect to be able to detect a cause such as a "prime mover". On the other hand the second question leads to an understanding of what is changing and how each aspect of the system fits into the change. This is where DST can be a powerful tool for increasing our knowledge of cultural phenomena. For example, almost every category of behaviour becomes elaborated in the transition to the Natufian. This indicates that a global mechanism is operating to produce the elaboration in the behaviour of Natufian groups. One clear exception is the category of burials, which do not exhibit any elaboration in the Natufian (beyond a dramatic increase in the number of burials at some sites). This suggests that Natufian burials are not a significant aspect of the social knowledge sphere of the Natufian cultural milieu. On the other hand, the PPN burials are distinctly different, and they display elaboration with respect to Natufian and earlier burials. This will be discussed in more depth in the next section. The synchronic analysis of burials at Mallaha that was presented in Chapter 7 indicated that the only detectable patterns in the burials could be adequately explained as functional similarities of the behaviour involved in the expedient disposal of the dead. In other words, there were no detectable patterns of behaviour that indicated that the burials at Mallaha contained an aspect of symbolic meaning to the living inhabitants of the site. The diachronic analysis presented in this chapter serves to confirm the analysis presented in Chapter 7 by demonstrating that when all of the socially significant behaviours become elaborated in the Natufian, the burials remain unelaborated.

8.2 COMPARISON OF BURIALS

The data presented from the first four sites discussed above (Abu Noshra II, Ohalo II, Neve David, and Mallaha) indicates that burials do not change with the advent of the Natufian, which is an exceptional condition since virtually all other aspects of Natufian culture are elaborated compared to the earlier sites. This section explores burials in more detail to demonstrate the similarity of early burials, to indicate that PPN burials are distinct from the earlier burials, and to use CSTC to explain what this means.

8.2.01 The Burials

Burial at Abu Noshra II

The Upper Palaeolithic site of Abu Noshra II does not contain a burial, but the Upper Palaeolithic burial from Nahal Ein Gev I can be used as a proxy. Several authors (Marks and Freidel, 1977; Bar-Yosef, 1983; Gilead, 1995) have suggested that the greater number of burials from Mousterian and Natufian sites is an indication of the more intensive use of some sites during these eras compared with the ephemeral nature of sites in the Upper Palaeolithic.

At Nahal Ein Gev I there was recovered a primary burial of a female, 30-35 years of age, placed on her right side, and her legs were strongly flexed towards her head. The burial contained three bovid horns near her left shoulder. There is a strong similarity between this burial, Kebaran burials, and Natufian burials (Arensburg, 1977; Gilead, 1995: 136).

Burial at Ohalo II

At Ohalo II the isolated bones of possibly two adults and one child were present, as well as one nearly complete burial (Nadel, 1995: 3). The nearly complete burial at Ohalo II was placed within a shallow pit (which is a common characteristic of burials before the Natufian era). The shallow nature of these graves may be due to the lack of an effective digging technology, or it may be another indication that these burials are simply an expedient disposal of the dead (a potentially hazardous and unpleasant material).

The intact burial (H 2) is described as a male age 35-40, and he was placed in a pit that is orientated with the head towards the north, the legs to the south, and the face to the east. The burial (H 2) is probably a secondary use of the bit. This is based on the photograph and description provided by Nadel (1994). There is approximately 20 cm of fill under the body that can be identified as cultural due to the fact that the fill contains numerous pieces of debitage and bone fragments. One of the bone fragments is incised and two stones are located under the skull, which has resulted in it being interpreted as a "ritual burial" (Nadel, 1994). On the other hand, a few other pieces of incised bone were found in other contexts at Ohalo II, but none of those contexts have been imparted with the "ritual" label.

Burial at Neve David

Two burials were discovered at Neve David, one was disturbed by later occupation of the site and the other was intact. The intact burial is the more completely described of the two. The individual is described as a 25-30 year old male, and he was placed on his right side in a tightly flexed position. The orientation of the pit is East-West with his head to the West and facing south. This burial is described as a "ritual burial" because it contained beads around the head and neck (Kaufman and Ronen, 1987: 337), three broken groundstone objects, and it is described as being marked by two parallel rows of stones (Kaufman, 1989). In addition, one groundstone piece (a deep mortar) is described as being placed over the head of the individual like a "helmet" (Kaufman, 1989).

Burials at Mallaha

At Mallaha 105 burials have been excavated (Belfer-Cohen *et al.*, 1991). The orientation of the burial pits varies dramatically and continuously so that no pattern of orientation can be detected. Figure 8.01 is a drawing of the burials that are designated as "Cemetery B" at Mallaha. It has been suggested that these burials are all from a relatively short time period, but as can be seen they have been placed in many different orientations and they vary from semi-flexed to fully flexed. Similarly the placement of the individuals within their pit varies continuously. The burials at Mallaha were placed on either side, on their backs, on their fronts, and one even appears to have been placed in a sitting position (Perrot, 1966). The only consistent pattern with respect to the placement of burials is that they all appear to have been placed in locations that are away from occupied structures, and this pattern can be accounted for in functional terms – the disposal of hazardous material. Some of the pits contain groundstone fragments, flint tools, bone tools, and even items of ornamentation made from quantities of beads. A significant number of burial pits contain fill that is best characterised as waste (such as the ashy deposits from hearth cleaning), and indicates that burial within these pits may be a secondary use of the pit. Pits that appear to be dug primarily for the purpose of burial are quite often placed in the fill of unoccupied structures.

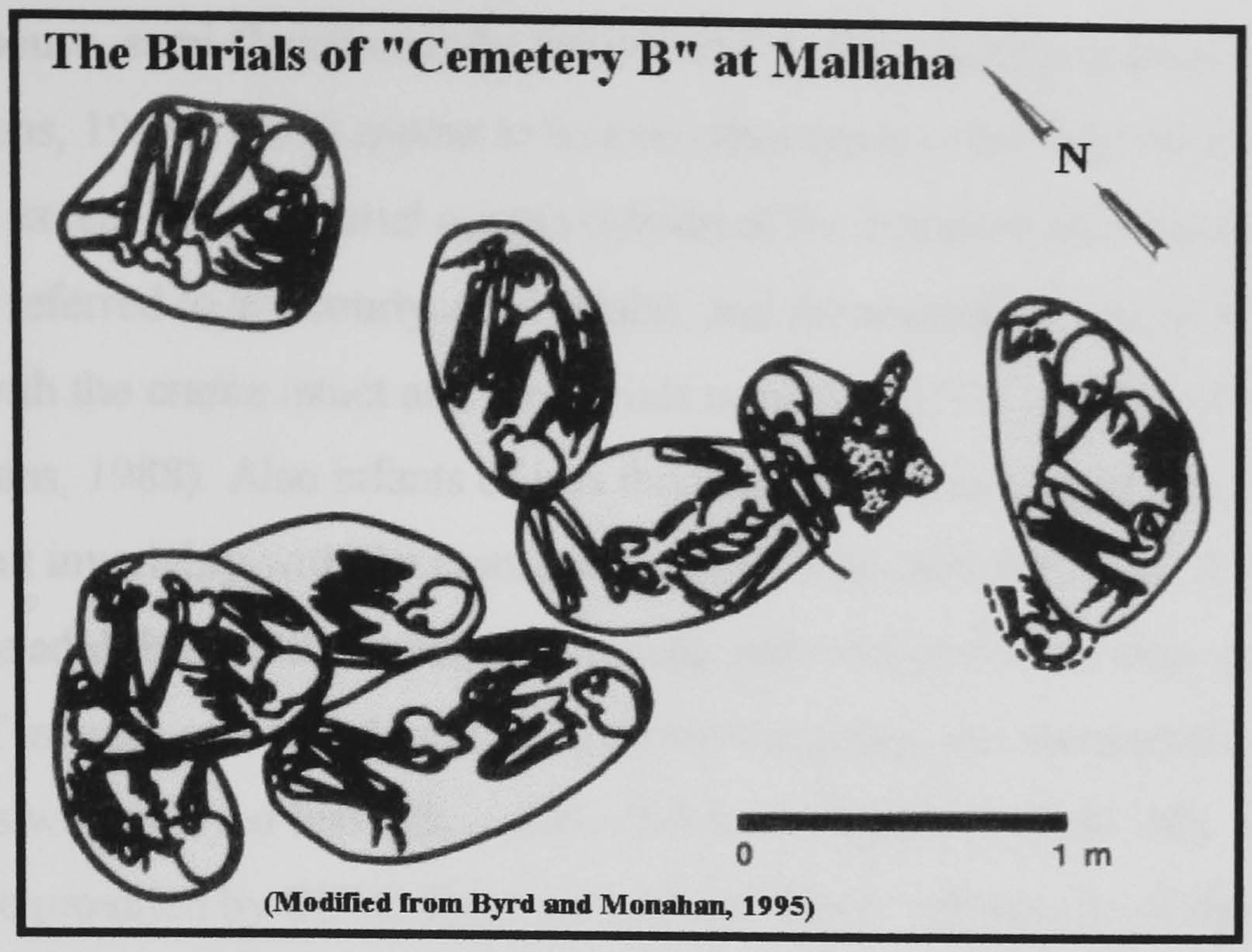


FIGURE 8.01 – This drawing depicts the burials that are designated "Cemetery B" at Mallaha (located beneath structure 131). This demonstrates the varying orientation, body position, and degree of flexion of the Natufian burials at Mallaha. (Modified from Byrd and Monahan, 1995)

Burials at Netiv Hagdud

At Netiv Hagdud 28 burials have been uncovered (Belfer-Cohen and Arensburg, 1991). The burials at Netiv Hagdud appear to have been placed either in open spaces or in the fill of abandoned houses or storage facilities, which indicates that they were placed in unoccupied spaces or in dumping areas (Bar-Yosef *et al.*, 1991). Burials were placed in either a semi-flexed or fully flexed position, and no consistent orientation of the graves or the body within the grave is evident. None of the burials contained grave goods, but a distinct pattern of skull removal is evident. All children were buried intact, but all adult burials are missing their crania (even though the mandibles are present) (Belfer-Cohen and Arensburg, 1991). The sole exception to this pattern of skull removal is H9, which is a young adult that retained its skull. It is not clear what purpose (if any) the crania served once they were removed. One skull was discovered in a dumping zone and three others were found inside the structure at Loc 8. Since this area of Loc 8 contained many objects that could be interpreted as waste this location may also have been a dumping zone.

Burials at Ain Ghazal

At Ain Ghazal nearly 75 burials have been discovered (Rollefson and Simmons, 1988). The typical burial consists of a single individual, placed under the floor of a house, semi-flexed or fully flexed, and with the crania removed (Rollefson and Simmons, 1988). There appear to be two other types of burials, the first is just as mentioned except that the burial occurs outside of the structure (sometimes these burials are referred to as "courtyard" burials), and the second is considerably different with the crania intact and the burials occurring in "trash pits" (Rollefson and Simmons, 1988). Also infants of less than one year were treated in a wide variety of ways, but invariably with the crania intact (Rollefson and Simmons, 1988).

The adult burials that retain their skulls and were placed in trash areas (instead of in areas associated with residential structures) are interpreted as individuals who enjoyed less status and/or respect (Rollefson, 1986: 50). From the perspective provided by CSTC these individuals clearly fall outside of the social structure indicated by the pattern of skull removal and burial in association with residential structures. Unfortunately it has not yet been demonstrated what the pattern of skull removal represents. This means that the non-typical burials could mean just about anything. For example, the individuals that are buried with their skulls intact could represent low status residents of 'Ain Ghazal, but they could just as easily represent non-residential individuals (such as visitors or travelling traders). We don't know what the typical burials represent so we have no way of knowing what non-typical burials are likely to mean.

Not only are there distinct patterns of burial, there is also clear evidence that the crania were treated to extensive alteration after removal. Several crania have been found in caches (some in subfloor contexts), some crania have residues of plaster and asphalt, and three plaster modelled faces have been recovered in a cache where they were placed after removal from the crania. Asphalt was typically used "as an eyeliner and to indicate irises" (Rollefson and Simmons, 1988). A wide variety of treatment of crania is recorded at Ain Ghazal. For example, in addition to the plaster modelling one cranium was covered with a black pigment and another with red ochre.

There also appears to be a connection between hearths and burials. Six burials were located in the 1983 season and all of them were within 1.5 meters of the structure's central hearth. Subsequent excavations have demonstrated that this relationship appears to have been unique to one or two structures, but all subfloor burials discovered to date at 'Ain Ghazal have been found in the room of the house that contains the central hearth. In square 3079 four successive burial-and-hearth-building episodes have been identified, and in several instances the burial was placed so close to the hearth that the hearth was damaged so that the hearth had to be rebuilt or repaired.

'Ain Ghazal also contained several large plaster statutes. Based on the similarity between the faces of the statues and the plaster faces from crania they may be connected (possibly both part of an "ancestor cult" [Rollefson and Simmons, 1988]).

8.2.02 Discussion Of Burials

The data presented for mortuary behaviour includes the Upper Palaeolithic through the PPNB, and it takes the form of burials. All of the burials discussed are put forward as representing "typical" burials for each era. These burials have a number of very similar aspects. Figure 8.02 presents data on the aspects of these burials that remains constant throughout this long time span. The data for the Natufian is the most representative, and it indicates that these aspects of burials are quite random. The data for Netiv Hagdud does not display the same randomness as the Natufian data does, but this is an artefact of the published data. The descriptions of the burials at Netiv Hagdud indicate that these burials were also random for the parameters presented in Figure 8.02 (Belfer-Cohen and Arensburg, 1991). This represents an unchanging similarity in the burials from the Upper Palaeolithic through the PPNB. These fundamental aspects of burials (degree of flex, position of body, orientation of the grave, and association with grave goods) vary randomly, and they cannot be correlated with other aspects of burials (such as age or gender). From this perspective the pre-Natufian burials are indistinguishable from Natufian burials, and PPN burials are largely indistinguishable from Natufian and pre-Natufian burials. In general Figure 8.02 demonstrates the random nature of burial behaviour, and the high degree of similarity of these aspects of burials through time.

At the beginning of the Natufian a dramatic transformation of behaviour is evident, as discussed earlier in this chapter. Almost all aspects of behaviour and the associated material cultural become more elaborate with the advent of the Natufian. One notable exception to this is burials. There is no discernable elaboration of burial behaviour in the Natufian. There is merely a quantitative change in the number of

Burial	Number	Semi	Full	Left	Right	Back	North	South	East	West	Bead
Ein Gev I											
1	NA		1		1		nd				0
Ohalo II											
1	NA	1				1	1				0
Neve David											
1	NA		1		1					1	y
Mallaha											
1	6a	nd	nd	nd	nd	nd	nd	nd	nd		25
2	6b	nd	nd	nd	nd	nd	nd	nd	nd		10
3	15	1				1	1		?		0
4	19	1				1	1		?		25
5	23	nd	nd	nd	nd	nd	nd	nd	nd		8
6	43	1		1				1			70
7	66		1		1				1		0
8	80	1			1		1				0
9	81	1		nd	nd	nd	nd	nd	nd		0
10	82	1		nd	nd	nd	nd	nd	nd		0
11	87		1	1				1			35
12	88	?	1	1					1		75
13	89	1		1					1		25
14	90		1	1				1			0
15	91	1			1				1		45
16	92	nd	nd	nd	nd	nd	1				0
17	97		1		1			1			0
18	98		1		1			?	1		0
19	104		1		1		1				0
20	105	nd	nd	1				1			0
Netiv Hagdud											
1	2		1		1		nd				nd
2	3		1	1			nd				nd
3	7		1	1			nd				nd
4	8		1	1			NW				nd
5	9		1	nd			nd				nd
6	11		1	1			nd				nd
7	12		1		1		nd				nd
8	18		1	1			nd				nd
9	21		1	1			nd				nd
10	21a		1	nd			nd				nd
11	22		1	1			nd				nd
12	24		1	nd			nd				nd
Ain Ghazal											
1	127	1				1	nd				nd
2	nd	nd		nd			nd				40

FIGURE 8.02 – This table compares the fundamental aspects of the burials from the Upper Palaeolithic through the PPNB. (NA = Not Applicable; nd = no data)

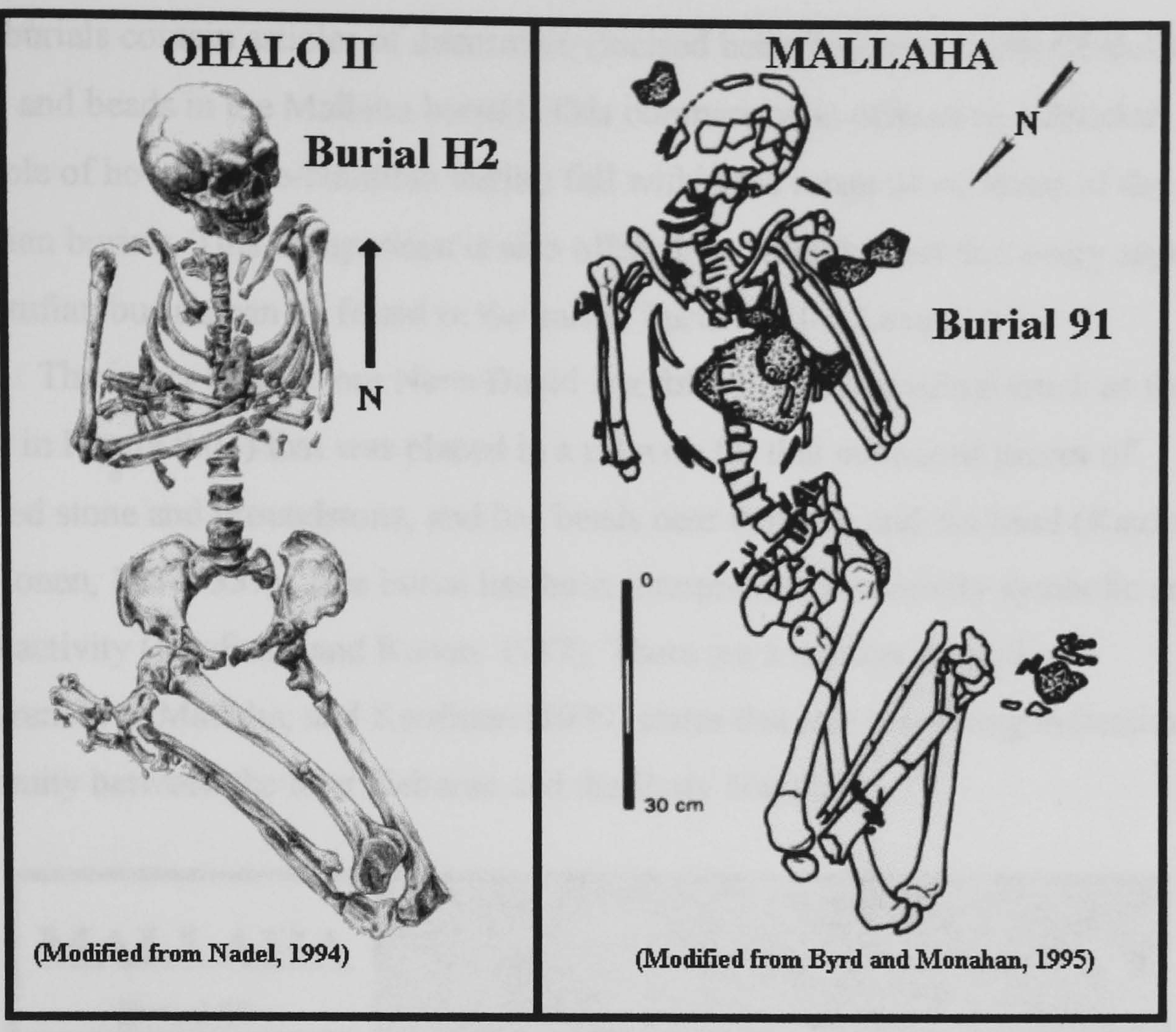


FIGURE 8.03 – Comparison of the semi-flexed burial from Ohalo II to one from Mallaha, which demonstrates that the Ohalo II burial falls within the range of variation of Natufian burials. (Modified from Nadel, 1994 and Byrd and Monahan, 1995)

burials at Natufian sites, which can be attributed to a functional aspect of site occupation. Some Natufian burials are ascribed with ritual behaviour because they contain bovid horns (as does the Upper Palaeolithic burial at Nahal Ein Gev I), some contain inscribed bone objects (as does the Ohalo II burial), some contain groundstone objects (as does the Neve David burial), and some Natufian burials contain beads (as does the Neve David burial). The data indicates that the Natufian burial behaviour at Mallaha contains nothing that is not present in pre-Natufian burials, and Natufian burials have a range of variation that encompasses all of the behaviour found in pre-Natufian burials. For example, Figure 8.03 is a comparison of drawings of the burial from Ohalo II and a burial from Mallaha, which demonstrates the similarities between the Ohalo II burial and some of the burials at Mallaha. Both burials in Figure 8.03 are semi-flexed, which means that only the lower legs are folded back. The rest of the skeleton is in an extended position. The arms are positioned up by the chest, and not extended along the body. Both crania are facing in an easterly direction, even though the orientation of the bodies is quite different.

Both burials contain articles of decoration (incised bone fragment in the Ohalo II burial and beads in the Mallaha burial). This comparison is offered as a detailed example of how the pre-Natufian burials fall within the range of variation of the Natufian burials. This comparison is also offered to stress the fact that every aspect of Natufian burials can be found in the earlier burials in the Levant.

The intact burial from Neve David is a fully flexed individual (such as the burial in Figure 8.04) that was placed in a pit with fill that contained pieces of chipped stone and groundstone, and has beads near the neck and the head (Kaufman and Ronen, 1987: 337). This burial has been interpreted as a socially symbolic and ritual activity (Kaufman and Ronen, 1987). There are a number of similar occurrences at Mallaha, and Kaufman (1989) states that this is a strong indication of continuity between the later Kebaran and the Early Natufian.

FIGURE 8.04 – An example of a fully flexed Natufian burial from the site of Mallaha. (Modified from Perrot, 1966)

Figure 8.04 is an example of a fully flexed burial from Mallaha. Unfortunately no equivalent photograph of the fully flexed burial at Neve David is available for comparison. It is clear from the description of the Neve David burial that it is virtually identical to several of the burials at Mallaha, which also contain beads and fragments of groundstone objects.

In Chapter 7 I concluded that the Natufian burials were simple expedient acts of disposal. The indisputable fact is that it is irrelevant whether an interpretation stressing expedient disposal or one proposing symbolically significant social ritual is favoured. From either perspective the burials at Nahal Ein Gev I, Ohalo II, and Neve David are indistinguishable from the Natufian burials at Mallaha. The comparison of information level at the beginning of this chapter indicated that at the beginning of the Natufian most aspects of material culture became elaborated to a significant degree. One notable exception to this is the burial behaviour. Throughout the Natufian the burials remain virtually unchanged, and the Natufian burials are indistinguishable from the burials at Nahal Ein Gev I, Ohalo II, and Neve David. This means that burial behaviour does not become elaborated in the Natufian, which indicates that the burials are not part of the socially constrained behaviours of the occupants of the sites. In other words, burials are a background behaviour that remains in the equilibrium condition of the pre-Natufian cultures. To demonstrate this point we need only examine the burials from the PPNA and the PPNB.

Burials at the PPNA site of Netiv Hagdud are very similar to Natufian burials, but there are two important distinctions. The first distinction is that there is a pattern of cranial removal that is typical of PPNA burials. This is evident in Figure 8.05, a typical PPNA burial from Netiv Hagdud.

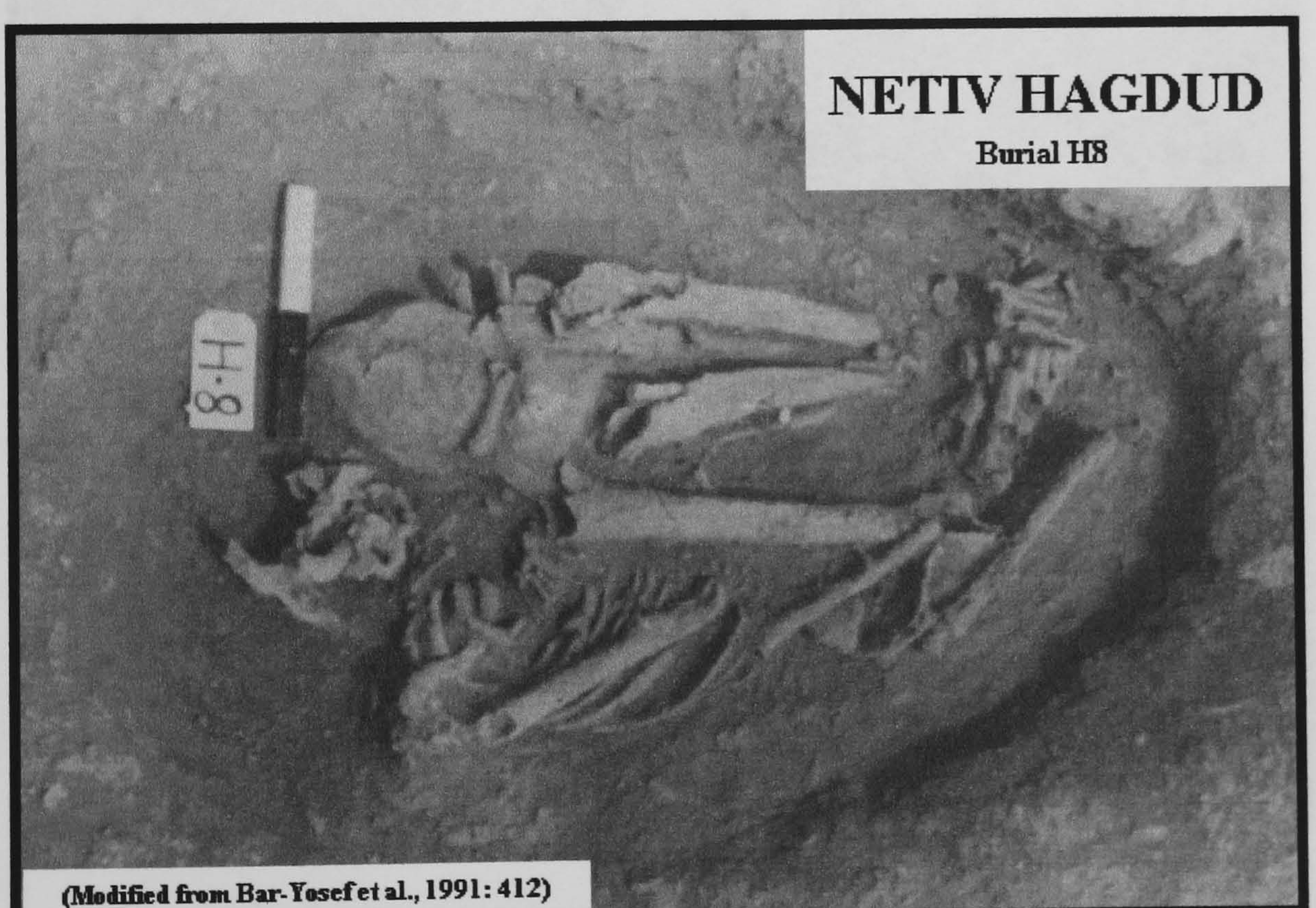


FIGURE 8.05 – A photograph of a typical PPNA burial from Netiv Hagdud. (Modified from Bar-Yosef et al., 1991)

This is a fully flexed burial of an adult at Netiv Hagdud. The skeleton is nearly complete, including the presence of the mandible, but the cranium has been removed.

Except for the removal of the crania the PPNA burials at Netiv Hagdud are indistinguishable from the Natufian burials at Mallaha.

The second distinction between PPNA burials and Natufian burials is the significance of the pattern of cranial removal. At Netiv Hagdud all of the adult burials are missing their crania (except H9). In contrast, the burials of individuals that are less than 10 years of age retain their crania (Bar-Yosef *et al.*, 1991: 412). This is the first clear indication that some aspect of burial behaviour is constrained (or structured) by the social organisation of the group. This pattern of cranial removal suggests that the social organisation of the PPNA recognises a status distinction between adults and children. Further more, this distinction is expressed in burial behaviour. No equivalent distinctions can be demonstrated in the Natufian burials, but this behaviour does become more elaborate in the PPNB.

The burials at 'Ain Ghazal seem to be typical for the PPNB (Rollefson, 1983). Figure 8.06 is a photograph of one of these burials.

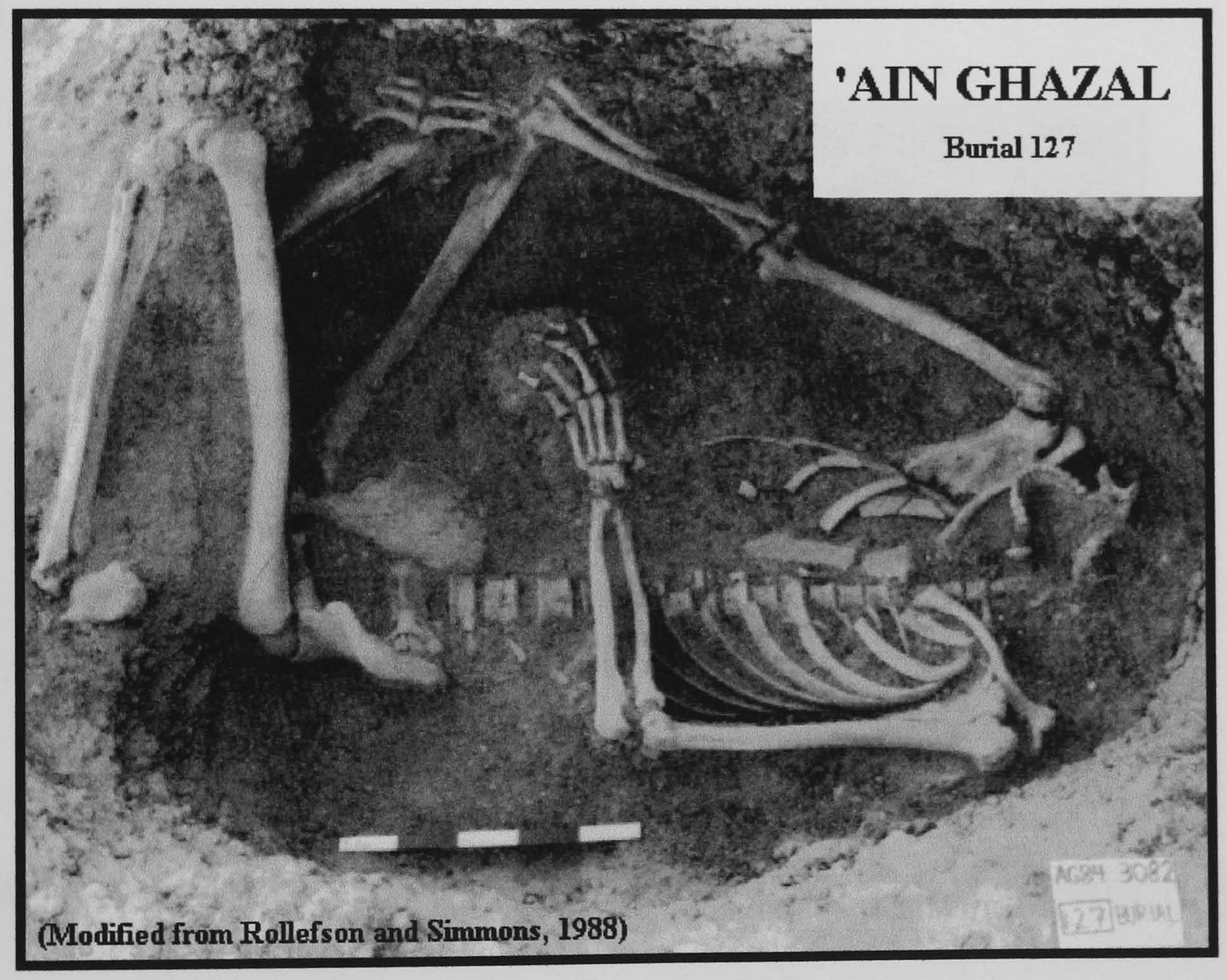


FIGURE 8.06 – A Photograph of a typical PPNB burial from 'Ain Ghazal. (Modified from Rollefson and Simmons, 1988)

This PPNB burial is better preserved than the PPNA burial in Figure 8.05, and it is obvious that the skeleton is intact, including the mandible, but the cranium has been removed. Comparing Figure 8.04 and Figure 8.06 demonstrates that the adult burials from the PPNA are indistinguishable from those of the PPNB. They are both fully flexed burials with the mandibles present but with the skulls missing. In this respect the PPNA and PPNB burials are virtually indistinguishable from each other but very distinct from Natufian burials. Griffin describes the PPNB burial process as follows:

> "Removal of the skull occurred some time after initial internment. Graves were reopened above the head, and the upper portion of the skull was removed, leaving the mandible with the body." (Griffin, 1998: 60)

There is at least one unequivocal example of this sequence of events at 'Ain Ghazal (Banning, 1998: 223). Since PPNA and PPNB burials are virtually identical with respect to skull removal it is reasonable to suggest that the process of skull removable described by Griffin was also employed in the PPNA. This presents a picture of burials becoming part of a socially constrained information network, and though we have almost no information about the use of skulls in the PPNA the PPNB provides us with examples of very elaborate behaviour involving the skulls of the dead.

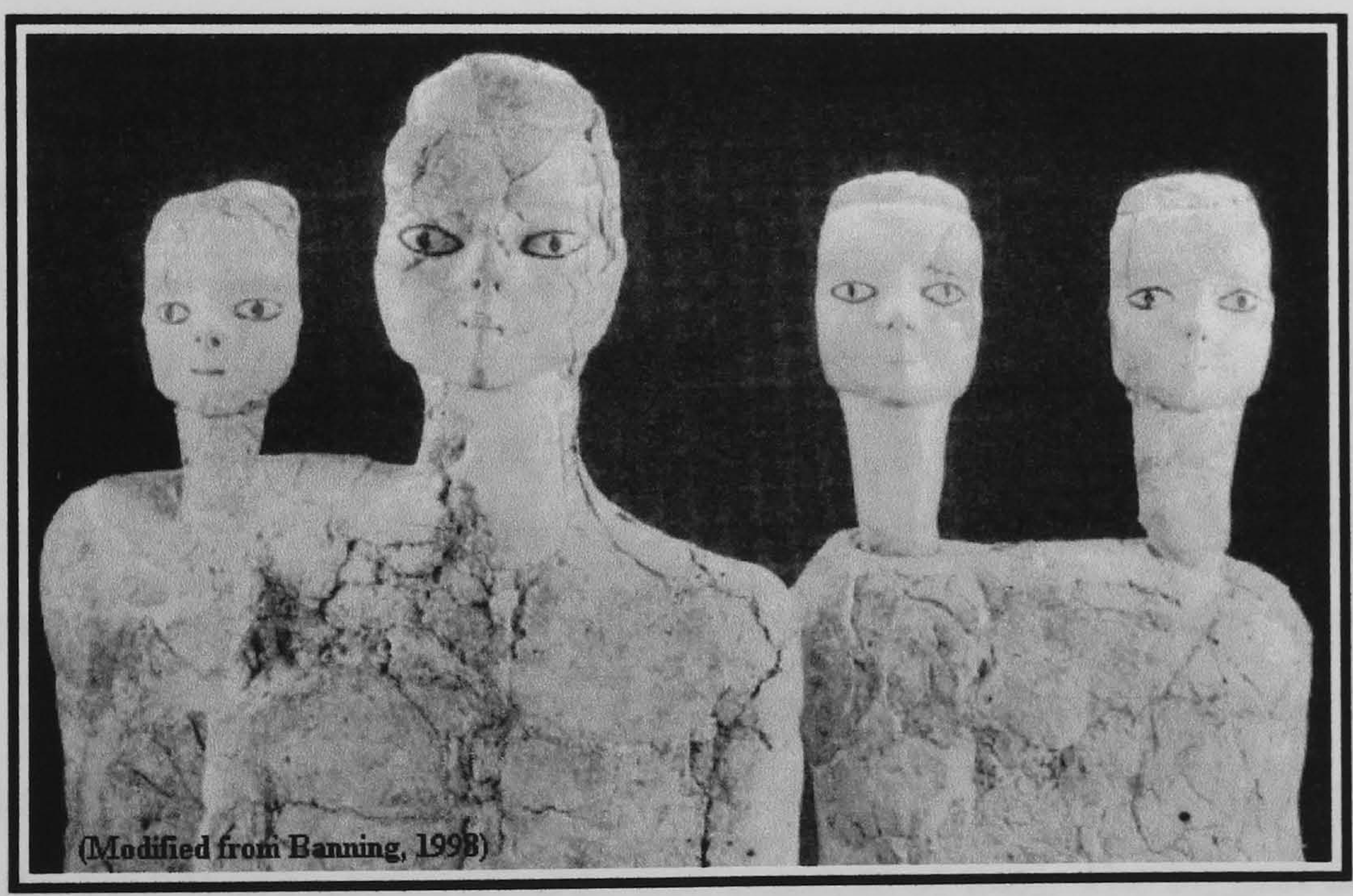


FIGURE 8.07 – Reconstructed plaster statues from 'Ain Ghazal. (Modified from Banning, 1998)

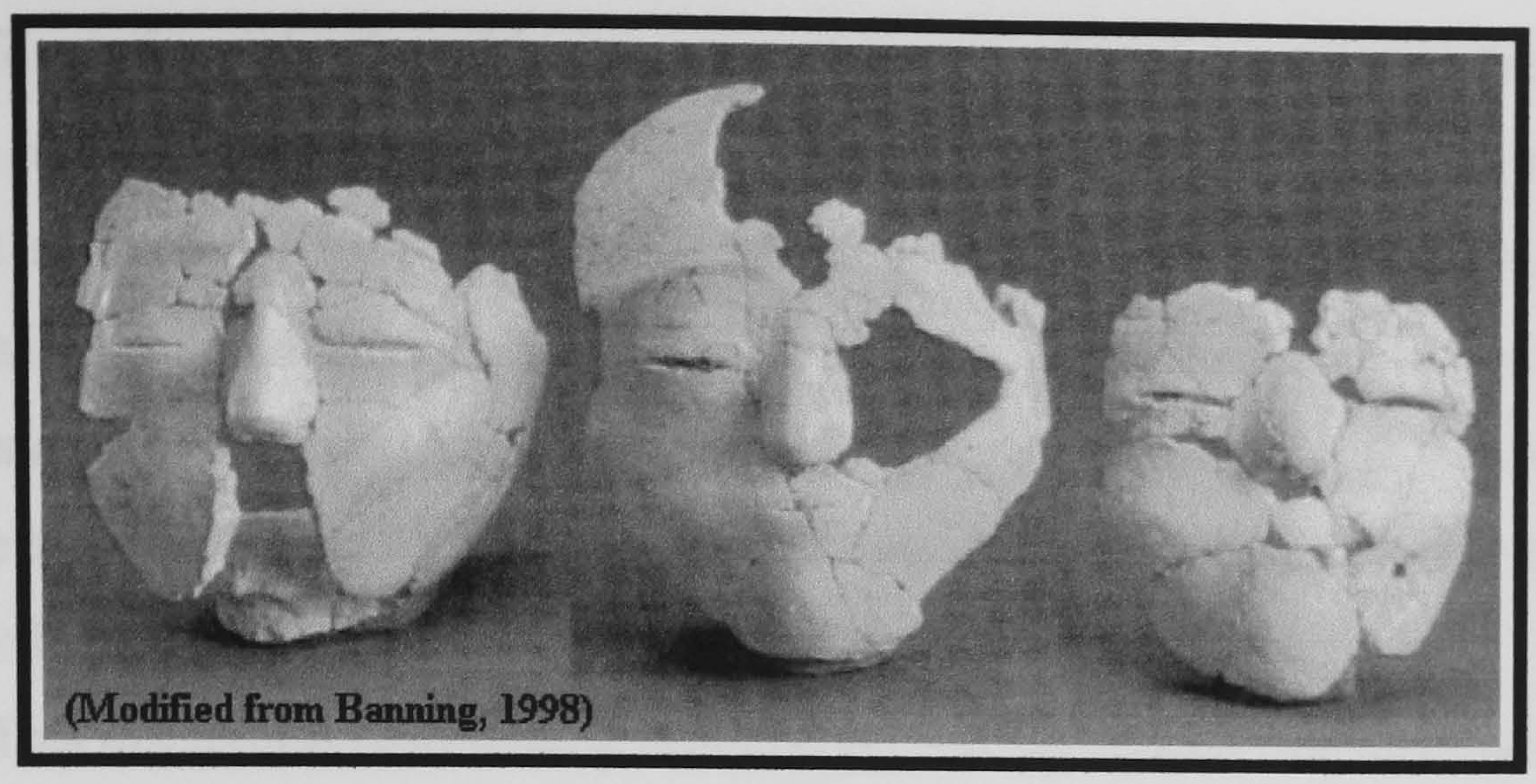


FIGURE 8.08 – Partially reconstructed plaster faces of skulls from ‘Ain Ghazal. (Modified from Banning, 1998)

Several PPNB sites have produced plastered skulls, but ‘Ain Ghazal has also produced three plaster faces that had been removed from their skulls and buried together in a cache. The plaster faces all retain the impressions of the skulls (and the materials used to prepare the skulls for plastering) on their interior surfaces. The faces also seem to have been broken in the process of removing them from their skulls.

‘Ain Ghazal presents data that has been used to connect the construction of plaster statues to the practice of plastering skulls. Figure 8.07 is a photograph of some of the plaster statues from ‘Ain Ghazal. Comparing them to the plaster faces from ‘Ain Ghazal (Figure 8.08) reveals several points of similarity. The statues and plastered faces are obviously not realistic “portraits” or natural representations of people. They are highly stylised and some of their features are quite abstract. The mouths are most often represented by horizontal slits, the nostrils are also most often just slits, and the brows are stylised ridges. When their ears are represented at all, they are little more than a featureless pinch of plaster on the side of the face (the statue to the far left in Figure 8.07 is a good example of this). The biggest difference between the statues and the plaster faces is the eyes. Although both typically employ some black pigment, the eyes of the statues are open and the eyes of the masks (again mere slits highlighted with black pigment) are closed. If the statues and faces are considered together they could be interpreted as abstract representations of the living and the dead (Banning, 1998: 223).

Another aspect of the ‘Ain Ghazal burials is that there appears to be three distinct forms for adult burials. The typical burial is found beneath the floor of a house, in the room containing the central hearth, and with the cranium removed. The second form of burial is found in open spaces outside of houses, and with their cranium removed. The third form of burial is found in "waste pits" with their crania intact. It is not clear what these burial types represent, but there is a strong suggestion of increasing elaboration of social organisation that is being displayed in the burial practices at 'Ain Ghazal. There is supporting evidence for this view, and it comes from the architecture at 'Ain Ghazal. This aspect of burials will be addressed in more detail in the following section of the present chapter.

This discussion represents a very limited and superficial treatment of burials, but it does demonstrate the usefulness of CSTC as a tool for investigating cultural phenomena within the archaeological record. CSTC prescribes a specific perspective for analysing cultural data (the information perspective), and CSTC provides an explanation of what a pattern of information (or the lack of a pattern) means. This constrains research to specific types of questions, which is very different from a paradigmatic methodology that admits any and all questions. Natufian burials (and their predecessors) display no discernable pattern of information that could be used to indicate that this behaviour is part of a socially constrained sphere of knowledge. This is indicated by the random variation in all aspects of burials, and in the fact that burials do not become elaborated along with all other aspects of socially controlled knowledge at the advent of the Natufian.

The first indication that burial behaviour is becoming part of the socially constrained sphere of knowledge occurs when the practice of skull removal becomes evident as an aspect of a typical PPNA adult burial. It is also significant that all other aspects of burials in the PPNA remain random, which makes them just like the Natufian burials in all aspects except skull removal. The significance of the pattern of skull removal in the PPNA is highlighted by the pact that the practice becomes elaborated in the PPNB with the use of plaster faces and possibly plaster statues. Burial behaviour in the PPNB also takes on an additional dimension with the typical association of burials with residential structures. Yet all other aspects of burials in the PPNB maintain the random variation that is typical of all earlier burials.

8.3 COMPARISON OF STRUCTURES

In Chapter 7 the conclusion of my analysis of the Natufian structures at Mallaha was that they exhibit the characteristics of information flow that are indicative of a system at or near a condition of equilibrium. In this condition information flow is equivalent for all individuals in the group, and access to information can be characterised as "egalitarian". In other words, the information flow displays no patterned structure that can be characterised as privileged access to information by a select subset of individuals in the group. This represents a social organisation typical of one that stresses inclusive group participation in all or most activities. A comparison of structures from the Upper Palaeolithic through the PPNB provides a basis for evaluating continuity and possible change in social organisation.

Even a superficial review of the archaeological data demonstrates that architecture became much more elaborate with the transition to the Natufian. The Upper Palaeolithic site (Abu Noshra II) displays no evidence of structures. Ohalo II (a transitional Upper Palaeolithic to Epipalaeolithic site) has clear evidence of three structures but they are so ephemeral that the existence of that data is probably due entirely to the high level of preservation at the site. The more substantial evidence for structures at Neve David (later Epi-Palaeolithic) suggests that an elaboration of architecture is beginning prior to the Natufian, but it is in the Natufian that structures display large amounts of elaboration. For example, it has been suggested that there are approximately 50 dwellings at Mallaha (Perrot, 1966). The typical dwelling is six meters in diameter and excavated into the sediments approximately 70 cm. This involves the removal of about 20 cubic meters of sediment. It is quite possible that the transportation of stones and their employment as a facing to the excavated wall is an effort equivalent to the removal of the sediments. Also, the procurement of materials and the construction of the superstructure could involve as much labour as either of the first two phases of construction. My estimate, based on personal experience[1], is that if 30 people worked together a typical dwelling at Mallaha could be constructed in just four to five days. On the other hand any one of the brush huts at Ohalo II could probably be constructed by just half a dozen people in as little as a single morning or afternoon.

As demonstrated in chapter 07 the structures at Mallaha display a striking similarity throughout the duration of the Natufian. With the advent of mud bricks the structures at the PPNA site of Netiv Hagdud display an increase in elaboration over the Natufian structures. Also, the shape of the structures seems to be more variable than in the Natufian. Never-the-less, the construction and use of dwellings at Netiv

[1] My personal experience includes ten years of estimating the time required to complete many different types of manual tasks within a manufacturing environment.

Hagdud is very similar, and this provides data that indicates that the flow of information is still near an equilibrium just as it was in the Natufian. As discussed earlier, social organisation in the PPNA may be more elaborate than it was in the Natufian (evident in the burial practice of cranial removal), but this is not reflected in the architecture of Netiv Hagdud. The PPNA burial practice of cranial removal demonstrates a clear distinction between adults and children, and it may indicate the advent of a ritual indoctrination into the "adult social sphere". It may be that such a ritual had existed before the PPNA, and it may be just becoming evident in the elaboration of burial practices of the PPNA. On the other hand, if burials had been nothing more than an expedient disposal of the dead, then an emerging new social organisation would be very likely to co-opt just such a previously symbolically neutral behaviour. This may become clearer by examining the elaboration of architecture and burial in the PPNB.

8.3.01 Consistency In Construction

Wall Construction

The walls of structures at 'Ain Ghazal are easily typified because they display very consistent construction sequences (see Banning and Byrd, 1984 and 1987; Rollefson and Simmons, 1988). The ground was levelled, and walls were constructed using a double-wall technique that provides a very even and vertical surface for both the interior and the exterior of the structure. The walls are constructed of undressed limestone slabs and cobbles, and held together with mud mortar. The spaces between stones (and also the core between the two surfaces of the wall) were filled with smaller rocks and mud mortar. In some places stones were placed across the core of the wall to hold the two surfaces of the wall together. Few walls were preserve to a height of more than one meter, but some upper portions of walls had remained intact after falling onto the ground. This evidence indicates that the walls were typically about 60 cm thick and roughly 2 meters in height.

The interior surface of the wall was smoothed with a layer of mud, and then finished with a thin layer of white lime plaster. It is possible that the exterior of the walls had been finished in mud and lime plaster, but traces have only been found on exterior walls that had once been interior walls [such as the west face of wall 3083.107] (Banning and Byrd, 1987).

The consistency of the construction of the walls is demonstrated across the site and for nearly a thousand years. As at the Natufian site of Mallaha this is an indication of an equilibrium form of information flow, which is typical of situations where large numbers of the occupants of the site participate in an inclusive group activity (such as wall construction seems to be at ‘Ain Ghazal). Not all members of the group need to engage in all aspects of wall building to achieve equilibrium information flow. It is sufficient that nearly all members participate fairly regularly in some aspects of the primary, secondary, or tertiary tasks of wall building. This provides the majority of the individuals an opportunity to attain an equivalent amount of information/knowledge about the wall building tasks. This indicates that the social organisation in the PPNB at ‘Ain Ghazal maintains an aspect of inclusive group participation. This is also seen in the construction of floors.

Floor Construction

The construction of floors is very similar in all structures of the PPNB at ‘Ain Ghazal (Banning and Byrd, 1984 and 1987). The floors are consistently prepared with a levelled layer of rubble, typically 3-4 cm thick, containing a mixture of small gravel, flint debitage, and bits of old plaster. The rubble was covered with a layer of coarse plaster, and where it met the base of a wall it was invariably curved upward to a height of 10-15 cm “giving the corners of rooms a distinctly bathtub-shaped appearance” (Banning and Byrd, 1984). In the final stage of construction the floors were finished with a thin layer (roughly 0.5 cm thick) of fine plaster, and burnished to a high gloss.

Another consistent feature of the floors was the inclusion of a hearth as an integral part of their construction (Banning and Byrd, 1984). The hearths are “bowl-shaped depressions” that are 10-14 cm deep and 70-90 cm in diameter (Banning and Byrd, 1984). A house in square 3067 displays five flooring events that maintain a consistent location of the hearth. House 8 (square 3079) also displays evidence of the consistent placement of hearths. This house has four hearth building events that are

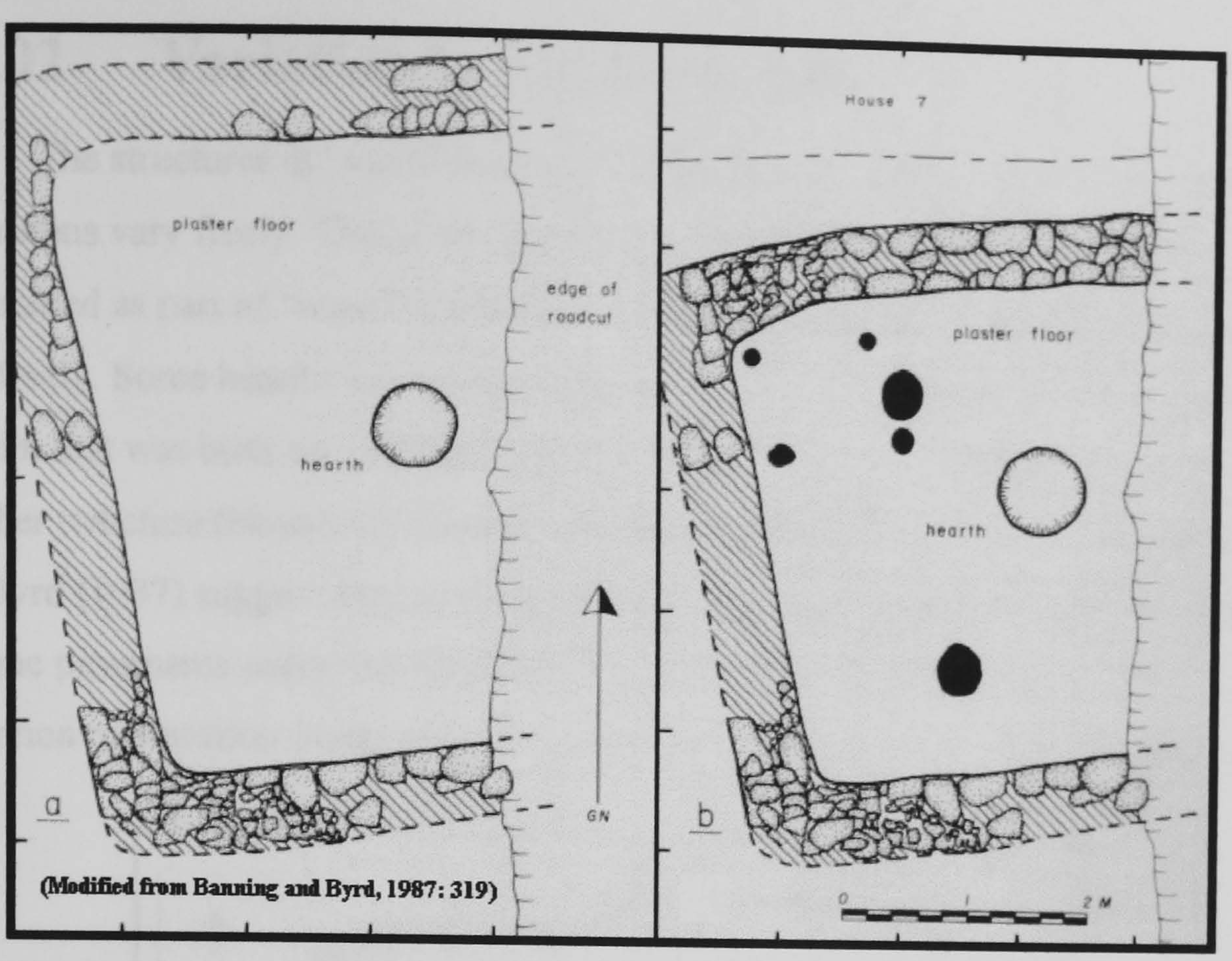


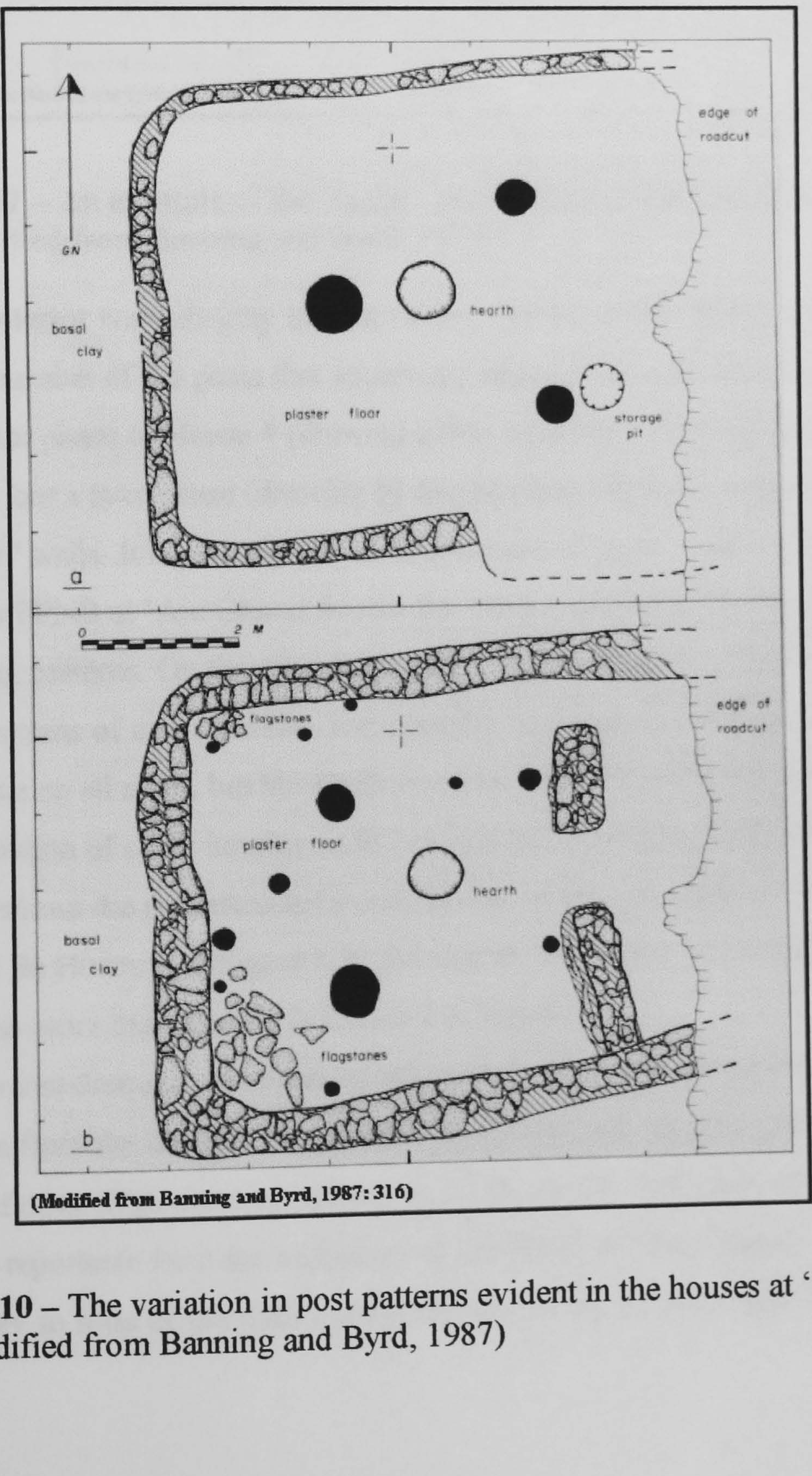
FIGURE 8.09 – Diagram of house 8 (a) before and (b) after moving the north wall and relocating the hearth. (Modified from Banning and Byrd, 1987)

almost right on top of each other. The last phase of House 8 also displays the consistency of hearth placement in the way the hearth is moved after a remodelling event. During remodelling of House 8 the north wall of the house was moved more than a meter to the south (reducing the size of the house), and the hearth was also moved to maintain a central location (see Figure 8.09).

Hearth placement, integration of hearths into floors, and similarity and consistency of wall construction all indicate a high level of information flow across the site. In other words, these behaviours display equal access to information and inclusive group behaviour that is indicative of an egalitarian social structure where access to information is roughly equivalent across the population occupying 'Ain Ghazal, and information is constrained by the social organisation and the inclusive participation in these activities. This is very similar to the condition at the Natufian site of Mallaha, but some of the activities at 'Ain Ghazal display distinctly differentiated behaviours and information which could indicate selective access to some information at this site. This is evident in the variation found in some elements of the structures at 'Ain Ghazal, and will be discussed next.

8.3.02 Variation In Construction

The structures at ‘Ain Ghazal are consistently rectangular, but the size and dimensions vary freely. This is an aspect of structures that does not seem to be constrained as part of “social knowledge”. Also certain features of hearths seem to vary freely. Some hearths have partial lips (House 4), and one hearth (House 8) has a low rim that was built up with clay and stones before it was covered with plaster. Another structure (House 12) displays some unique “curbs” in its floor that Banning and Byrd (1987) suggest may have served to drain water through a doorway. The use of stone pavements under the plaster of some areas of a few floors is another indication of variation found in floor construction activities (see Figure 8.10(b)).



(Modified from Banning and Byrd, 1987: 316)

FIGURE 8.10 – The variation in post patterns evident in the houses at ‘Ain Ghazal. (Modified from Banning and Byrd, 1987)

Posts that are probably supports for the roof display a variety of patterns. In some houses they are arranged in groups of three or four, but in other houses they are placed in alignments close to the exterior walls. Figure 8.10(a) displays a three post (triangular) pattern, but it is replaced by a version of the four post pattern where two of the posts are "pier" walls (Figure 8.10(b)). A third type is displayed in Figure 8.11, where three posts are arranged in an alignment along the wall.

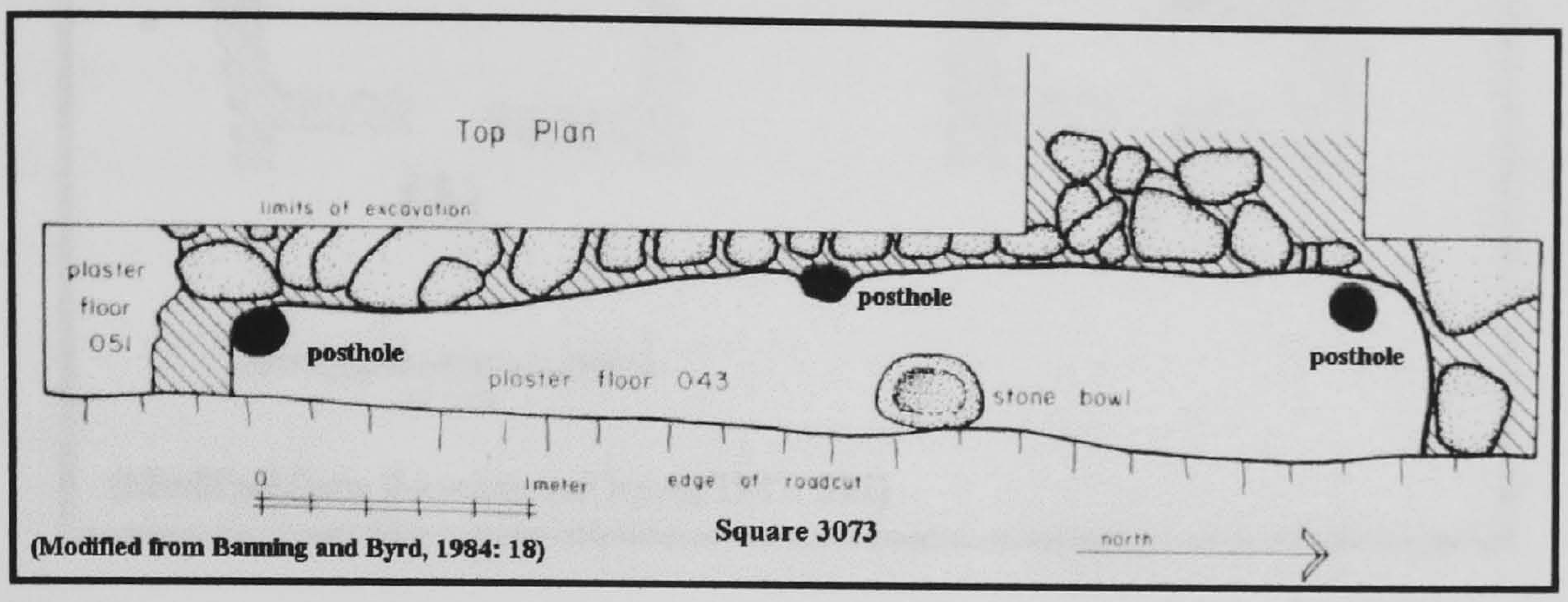
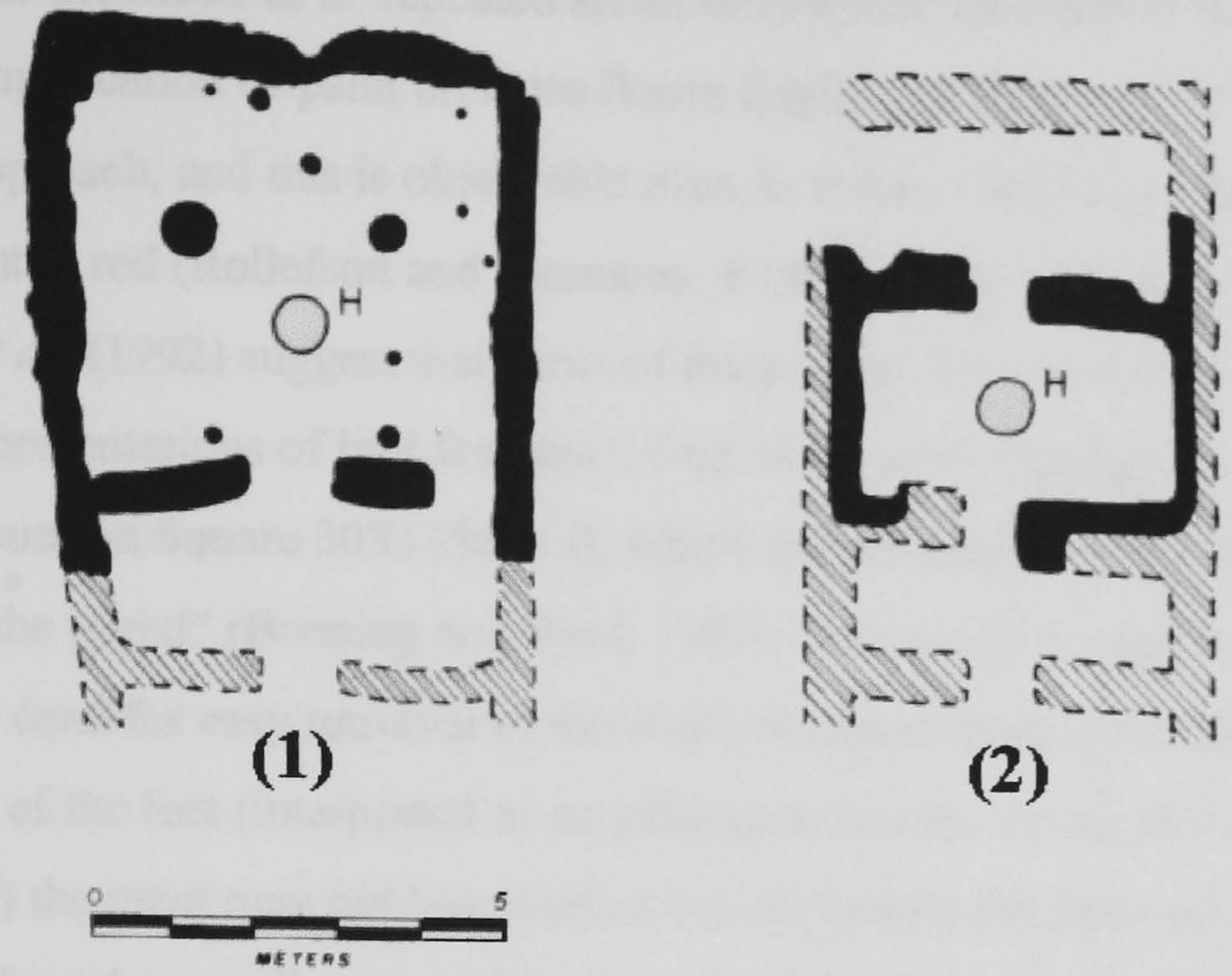


FIGURE 8.11 – An example of the "linear" posthole pattern at 'Ain Ghazal. (Modified from Banning and Byrd, 1984)

The interior walls display quite a variety of placements. Some of them seem to replace a number of the posts that apparently support the roof (House 4). In Figure 8.10 the earlier phase of House 4 (drawing a) has a pattern of three large posts for roof support, but a later phase (drawing b) displays two aligned posts and two aligned "pier" walls. It is also significant that the use of "pier" walls in the early phases of the PPNB at 'Ain Ghazal breaks the interior spaces of the structure in freely varying patterns. On the other hand, the later phases seem to have more consistent patterns of interior walls. For example, in Figure 8.10(b) the north pier wall has space on all sides, but the south pier wall is built against the exterior wall. The configuration of some interior walls is much more consistent and symmetrical. Figure 8.12 shows the reconstructed configuration of interior walls in two houses at 'Ain Ghazal. In House 1 of Figure 8.12 the interior walls vary in configuration and spacing much more than they do in House 2 of Figure 8.12.

The most dramatic examples of unique behaviour that are associated with houses come from the decorations on walls and floors, and the placement of burials through the floors. Wall painting appears to be an activity that was part of the behavioural repertoire from the beginning of the PPNB at 'Ain Ghazal. Unfortunately so little of the walls containing plaster has survived that the data is too



(Modified from Banning and Byrd, 1987: 311)

FIGURE 8.12 – Examples of interior wall placement at two houses from 'Ain Ghazal. (Modified from Banning and Byrd, 1987)

limited to provide substantial interpretations (Rollefson and Simmons, 1988). What little evidence there is suggests that wall decorations were limited to paint, and the designs varied freely. Apparently not all walls were painted, and not all replastering episodes of a wall were painted. In Square 3073 the Phase II occupation walls of the house were painted entirely red (Banning and Byrd, 1984). At least the lower portions of House 11 were painted red, and in House 7 the wall surfaces around a doorway were painted with "decorative geometric designs" (Banning and Byrd, 1987). The data may be limited, but it clearly suggests the unique and individual nature of the wall decorations in houses at the PPNB site of 'Ain Ghazal.

Floors of houses were also decorated with paint in a variety of ways. In Square 3067 the floor of a house was replastered at least 5 times, and each displays evidence of having been painted (Banning and Byrd, 1984). The floors of some houses were completely covered with red paint, but others display only small areas that were painted. In Square 3073 the Phase III floor is decorated with paint that appears "as arcs and short linear alignments of dots" (Banning and Byrd, 1984). Banning and Byrd (1987) mention evidence that some floors had "spectacular coloured designs" (two floors in House 12 [Square 3073] and one in House 2 [Square 3285]). In one phase of House 4 the hearth displayed a rim that was painted with a faint band of brown pigment (Banning and Byrd, 1987). One house floor contains a pattern that is described as a "repeated series of *commas*" (Rollefson and Simmons, 1988). The application of paint on these floors displays evidence of a "finger painting" approach, and this is observable even in some of the floors that were entirely painted red (Rollefson and Simmons, 1988; Rollefson *et al.*, 1992). Rollefson *et al.* (1992) suggest that some of the painted designs on floors resembled "stylised representations of bird feathers". One of the most significant applications of paint was found in Square 3083 Phase II, where the red paint was "restricted to the area above the burial" (Banning and Byrd, 1984). This could be significant for locating the dead for easy retrieval of the skull, but since several burials display disturbance of the feet (interpreted as an indication that the wrong end of the burial was opened) the paint may not have been a burial marker, the paint may have only marked the burial generally, or marking burials with paint may not have been a consistent practice at the site. An interesting aspect of painted floors is that when the entire floor is painted red, the paint is even applied to the bottom of the hearth.

There is only one known occurrence of a sub-floor burial that apparently has its location marked by paint on the floor (Square 3083). Although this is a unique occurrence, it strongly suggests a connection between the elaboration of the decoration of houses and the elaboration of burial practices in the PPNB. Burial in the house may be consistent for a given house, but it appears to be a unique and individual characteristic of each house. For example, in House 8 (Square 3079) four successive burials are nearly on top of each other and in very close proximity to the hearth. In Square 3082 three individuals (two adults and a child) were interred in at least two pits that intersected, and another individual (burial 127) was placed farther away from the hearth so that it did not disturb or intersect the other burials. In Square 3083 two burials are located within close proximity of associated hearths. Some burials were placed very close to hearths, but other burials, while in the room with the hearth, were placed along one of the walls of the room [i.e. burials in Squares 3067, 3076, and 3078 (Rollefson and Suleiman, 1983)]. One burial was placed in the corner of the room that contained the hearth. The evidence demonstrates that there is a correlation between burials and the hearth (if nothing more than its presence in the room with burials), but the burials range from being so close that they disturb the hearth to being as far from the hearth as possible. Many of the burials are placed to the south of the hearths, but this is not a consistent pattern for they are found on all sides of the hearth.

The data discussed here indicates that some aspects of the construction and the use of structures in the PPNB is very uniform, but other aspects of the construction and the use of structures either varies freely or displays a consistency that is unique to a particular house. This presents us with data that indicates that some activities are part of a site-level structure of social organisation, but that other activities may be constrained at a residence-level structure of social organisation. Other activities seem to vary freely, and that indicates that they are not constrained by social organisation.

It is the contention here that these patterns of organisation at different levels of interaction will also be evident in other aspects of behaviour and information flow at 'Ain Ghazal. If the house is emerging as a focus for some levels of activities or production then other indications should be found. Lithic production probably has the best chance of displaying these patterns of social structure. This should appear as tools that are very similar across the site, but the specifics of production of the tools should vary from residence to residence. In other words, we would expect to find high levels of similarity for the finished tools, but distinct sequences of production for each distinct production area. This demonstrates one of the important aspects of a scientific theory, the ability to predict, generate hypothesis, and direct research to test predictions and hypotheses.

8.4 LITHIC EVIDENCE FOR COMPLEXITY

CSTC is in the very first stages of being developed, and it is limited to a conceptual form of application. None-the-less, even at this stage CSTC promises to be a useful tool, and I will explore this potential by discussing the application of CSTC to lithic data. I have avoided discussing lithics in the body of this research for a number of reasons. The foremost is that lithic technology during the era that encompasses the origins of agriculture probably reached its most complex form. This means that new forms of lithic production are still possible, but the complexity of production techniques had probably approached a maximum. I will briefly engage the lithic data from 'Ain Ghazal because some researchers have suggested that it represents social complexity in the form of specialists producing a specialised lithic form – the naviform core.

By the Natufian the lithic technology encompasses such a large number of techniques and possible combinations of techniques that it cannot be addressed in a meaningful way by a rank amateur such as myself. In other words, the application of CSTC to lithic production will require technicians who understand the principles of CSTC and who have an expertise in reconstructing the techniques and sequences of production that are involved in lithic production. None-the-less, CSTC can be used to generate a testable hypothesis about the use of lithic data in archaeological research.

My understanding of lithics as a complex behaviour allows the following hypothesis to be generated by CSTC. Lithic production is a complex behaviour with many techniques that can be employed in many different combinations to produce very similar end products. Also, a very limited number of techniques can be employed to produce a large number of different types of end products. This condition means that the consistent use of a specific set of techniques in lithic production can only result from being constrained as part of a cultural entity. From the CSTC perspective this means that an analysis of production techniques could allow researchers to reconstruct patterns of regional interaction between sites, relative levels of interaction within and between sites, and relationships of cultural descent within and between sites.

This reconstructive endeavour is not going to be an easy task, and it will require dedicated lithic investigators who understand CSTC. It will also require the development of a formal system for investigating the information content evident in lithic production. This endeavour will also require a fundamental change in field methodology. Lithic debitage has become one of the aspects of data collection that is typically discarded so that more resources can be used to investigate more "important" aspects of pre-historic behaviour (such as subsistence, burials, and architecture). From the CSTC perspective debitage (and its context) is the data that has the best chance of allowing us to reconstruct social relationships and possibly even personal behaviour in prehistory. A methodology that is similar to what I suggest is amenable to the CSTC approach has been presented by Quintero (1997).

The lithic debitage at 'Ain Ghazal has been analysed for indications of *craft specialisation*, which Quintero (1997) suggests is indicated by the presence of naviform cores. Quintero (1997) addressed the question of social differentiation through the concept of craft specialisation, and she suggested that the naviform core-and-blade production at 'Ain Ghazal might be a form of lithic production that was produced by a few *specialists*. She recognises the fact that tool typology is not useful for this type of analysis, and she suggests that an investigation of the production sequence could be usefully investigated through an experimental replication methodology.

The research at 'Ain Ghazal engaged 169 lithic loci, and the first task was to distinguish between loci that displayed core-production, core-reduction, or tool-production/refitting activities. The assumption was that patterns of debitage could be used as indicators of specific activities at a lithic locus (an assumption that is potentially testable within the context of CSTC, but it is only an argument within the paradigm used by Quintero). The second task was to distinguish between *chipping floors* and *workshops*. Quintero defines this distinction in the following way:

> "... chipping floors reflect the common, unspecialized production of cores, tool blanks, and/or tools as a normal aspect of a subsistence-based, lithic economy. They equate with work places of individual flintknappers who produced lithic items for their own or familial use. Workshops, on the other hand, are areas where specialist flintknappers produced lithic products for use by non-family members of the community... " (Quintero, 1997)

The frequency of production localities was used by Quintero (1997) to discriminate between chipping floors and workshops. The assumption here is that specialized workshop loci should be relatively rare compared to chipping floor loci (Quintero, 1997). A primary lithic loci could be the result of a number of crafters using an activity centre individually. To control for this possibility the debitage from a locus could be analysed for debitage character, production standardization, and flintknapping skill (Quintero, 1997).

169 Middle PPNB lithic loci from 'Ain Ghazal were evaluated and nine were selected as the most likely to represent primary naviform core reduction areas (Quintero, 1997). These nine loci contained very high levels of high quality flint (93.3-99.9%), but only one loci appears to have been a primary deposit of debitage from the production and reduction of naviform cores (Quintero, 1997). This deposit consisted of an extremely dense lens of debitage, approximately one-half meter thick, and its context was in an exterior location that was not associated with any structures (Quintero, 1997).

This analysis fails to make a distinction between specialized activity areas and specialized workers. The research only demonstrates that a special activity centre is indicated. In other words, the data can be explained by either specialists working at a restricted activity centre or by an unrestricted population using the activity centre to produce a single specialty item. This analysis did not engage the aspects of the research that could be used to demonstrate that this activity centre is both a specialty centre and a specialist centre. For example, CSTC predicts that specialist information will be acquired in places that restrict access to information. The fact that this activity centre is an exterior location seems to contradict the interpretation that it is a specialist activity centre, which would have preferential access to information. Quintero (1997) states that analysis of lithic production technique and skill level can indicate whether an activity centre is a specialty centre or a specialist centre. Quintero did not use these aspects of lithic analysis to demonstrate that the specialty centre was used by a restricted number of specialist workers. Quintero simply assumes this conclusion based on the production of naviform cores.

Quintero (1997) proposes a paradigm for using lithic data to indicate social complexity in the form of specialist crafters, but the analysis is neither compelling nor convincing because she fails to engage the most critical aspects of the paradigm – uniform production technique and skill level of workers. This methodology is based on an intuitive understanding of the meaning of the information contained in lithic debitage, which is not the same as a theory that explains the information content of lithic production. This methodology is remarkably similar to what would be generated using CSTC, but it is based on insightful assumptions instead of the explanations provided by CSTC. Lithic data may be a very important aspect of investigating issues of social complexity and social differentiation, but it is not yet adequately developed as a methodology. Integrating a theory, such as CSTC with this methodology could go a long way towards realising this goal.

8.5 CONCLUSION

The present chapter is an extension of Chapter 7. It provides a further demonstration of how CSTC can be used to engage archaeological data. The diachronic perspective provided by CSTC was introduced and used to discuss the data from six sites that span approximately 30 ky. CSTC explains how cultural systems should behave when they are near equilibrium, and CSTC explains how cultural systems should behave when they experience a transformation that moves them away from the equilibrium condition. The three pre-Natufian sites (Abu Noshra II, Ohalo II, and Neve David) represent the near equilibrium condition, and they display the characteristic low levels of quantitative change over a relatively long time span that is indicative of a system near equilibrium.

The Natufian represents a transformation that moves the cultural system away from the equilibrium condition. It is not clear what aspect of the cultural system is directly transformed because none of the direct data provided by the material record displays the characteristics of a qualitative change. On the other hand, it is evident that the transformation occurred in an aspect of the system that is fundamental to all aspects of behaviour because they all display a characteristic quantitative change by becoming more elaborate. The fact that burials do not become more elaborate in the Natufian is a clear indication that burial behaviour is not part of the socially constrained behaviour of the cultural system. In other words Natufian burials are not symbolically significant, and they are not part of the cultural system of constrained social knowledge.

The PPN sites (Nativ Hagdud and 'Ain Ghazal) represent the new and relatively stable condition of the cultural system that has been moved away from the equilibrium condition by the transformation in the Natufian. The changes that are evident in the PPNA are largely quantitative, but the rate of change is relatively larger and faster than the changes during the pre-Natufian equilibrium condition. The PPNB represents a dramatic elaboration in several aspects of behaviour. The two discussed here are burials and architecture. CSTC states that as a system moves away from equilibrium the changes to the system will become non-linear and transformations will become more likely. The data from the PPNA and the PPNB represents examples of the non-linear increasing rates of change that CSTS predicts. This demonstrates that the diachronic perspective provided by CSTC is an important tool for predicting, exploring, and explaining archaeological data.

This chapter is an extension of Chapter 7 in another important way. The analyses provided in Chapter 7 indicate that the social organisation of the Natufian site of Mallaha is characterised by homogeneous information flow. In other words, the inferred information flow represented by the archaeological data indicates that Natufian social organisation is largely unstructured. The diachronic perspective provided by CSTC was used to select the most likely aspects of PPNA and PPNB data that should display structured social organisation – architecture and burials. The data indicates that the behaviour associated with architecture and burials becomes very elaborate in the PPNB. If new social structures are forming then the aspects of behaviour that display the most change should be associated with the new structures of social organisation, and these behaviours should display indications of the emerging social structures.

The data discussed in this chapter indicates that burial practices in the PPNA display indications of socially constrained behaviour, which is evident in the pattern of skull removal. The pattern of skull removal indicates a social structure that distinguishes between adults and children. It is important to understand that there is a difference between distinguishing between adults and children and crystallising that distinction in a behaviour that has no obvious functional role in the difference between adults and children. The data presented here also indicates continuity in burial behaviour from the PPNA to the PPNB. Skull removal that is typical in the PPNA is continued in the PPNB and is elaborated by constructing plaster faces on the skulls and later burying the skulls (and sometimes the plaster faces). This indicates a continuity in the developing social structure from the PPNA to the PPNB, and it indicates that burials are becoming even more important as an aspect of social structure in the PPNB.

The discussion of the architectural data from the PPNB indicates that another form of structure seems to be emerging in the social organisation of these groups. The architecture at 'Ain Ghazal displays aspects of construction that seem to be constrained at a level of social organisation that is common to the entire site. On the other hand, some aspects of the construction of the interiors of the dwellings seem to be unique to the individual dwellings and may even represent patterns of behaviour that are constrained at the level of the residence. Burial within the residence is one of the aspects of behaviour that seems to indicate patterns of behaviour that are constrained at both the site level and the residence level. It also indicates that burials and architecture are becoming associated with each other. This association of desperate behaviours indicates that not only are multiple forms of social organisation appearing in the PPNB, but a behaviour such as burials may be assuming multiple roles in delimiting and reinforcing a number of social structures within that organisation. This conclusion is reinforced by Quintero's (1997) analysis of lithic data, which seems to indicate the presence of craft specialisation in the form of naviform core production.

Demonstrating that CSTC can be used to investigate social organisation, and that many types of social organisation may be investigated through this theory, means that the results of the analysis in Chapter 7 is not simply an artefact of this theory. This conclusion indicates that CSTC is a valid theoretical perspective for the analysis of archaeological data. One of the advantages of CSTC is that it engages the whole cultural milieu. This cultural inclusiveness means that the preliminary conclusion reached here can be tested by expanding the analysis to include other aspects of behaviour at 'Ain Ghazal. This type of expansion is not possible within a paradigmatic perspective because each activity would be view from its own particular paradigm, and the analysis of the different activities would not be comparable. A methodology that is theory-based, such as CSTC, represents an inclusive approach to research that produces knowledge within a testable and repeatable framework.

CHAPTER 9

CONCLUSION

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This research is fundamentally a theoretical project, and the main goal is to synthesise a theory that can be used to explain culture and cultural evolution. The time frame that encompasses the origins of agriculture in the Near East was chosen as a context that would provide a number of good examples of cultural transformations. This project is no small undertaking, and my supervisors felt that it was imperative to make this project substantially relevant to archaeological research by using the resulting theory to engage archaeological data. The combination of these two tasks represents an ambitious undertaking for a three-year research project. The result is that much of this research has been dealt with in a rather cavalier fashion. None-the-less, the work presented here is sufficient to validate the claims for this methodology, and to warrant further research employing the Complex-Systems Theory of Culture.

9.1 SUMMARY OF THE RESEARCH PROJECT

One of the fundamental assumptions of this research is that Archaeology could be a science in just exactly the same way that physics is a science. It is important to understand that this research is not engaging the argument about whether archaeology is or should be a science. I am simply using my model of *scientific theory*, as the most effective form of theory, to construct a general theory of culture, and it is only a secondary concern that I argue that theory is the key to achieving scientific research. One of the first tasks of this project was to outline my personal view of the philosophy of science (see Chapter 2). I make a distinction between science and all other methods for accumulating knowledge, which is based on my distinction between "paradigm" and "theory". A *paradigm* is a belief about a phenomenon, which in its most explicit form is an **argument** about that phenomenon. In contrast, a *theory* is an explicit **explanation** of a phenomenon. A scientific theory must explain a phenomenon in terms of itself, which means that the theory must posit realistic mechanisms that are inherent to the phenomenon that is being explained. An example of this is how Newton's theory explains the motion of objects from the objective perspective of the forces that act on the objects. This is distinctly different from the *argument* offered by Aristotle, which can be summarised as 'objects move because they are seeking their natural place in the universe'. Newton's theory is a valid form of scientific explanation, but Aristotle's paradigm is not.

The fundamental aim of a general theory of culture is to explain the patterns of similarity and variation that are observed as cultural entities. This is analogous to the fundamental goal of Darwin's theory, which is an explanation of the patterns of similarity and variation that are observable in biological organisms and species. Today Darwin's evolutionary explanation is based on the transmission of biological information, which is in the form of genetic material. The insight provided by this analogy suggests that cultural evolution might also be predicated on the transmission of information. It is important that the reader understands that the theory of culture that is presented here is a non-deterministic and conceptual form of theory, which is similar to Darwin's theory. This form of theory presents a stark contrast to Newtonian Mechanics, which is deterministic and it is rendered in a formal mathematical form. All three of these theories fulfil the fundamental requirements of *theory* as I have presented it, which is a conceptually objective explanation of a significant class of phenomena. Theory in this form is the most effective context for acquiring knowledge that has ever been devised by humans.

A belief that is commonly expressed in the literature is that the archaeological record provides an inferior or degraded data set. A basic assumption of the present research is that the archaeological record provides data that is as good as that which is available to any field of research. It is archaeological *theory* that is inadequate for investigating past cultural phenomena. A theory that explains cultural phenomena must do so from the perspective of the inherent mechanisms of culture. Implicit Learning Theory (ILT) explains the connection between information, knowledge, behaviour, and the material products of behaviour as part of the inherent learning process, which is a universal aspect of all humans – present and past. From this perspective cultural phenomena are produced by the transmission of cultural information that is displayed in behaviour and the material products of behaviour. This is important because at least part of the information transmission mechanism (the material products of behaviour) survives for archaeologists to interact with. The transmission of cultural information is a complex process, and at first glance it would seem that the result should be unintelligible chaos. Dynamical Systems Theory (DST) explains how complex systems self-organise into recognisable patterns that display continuity, variation, and even transformations to new and unexpected forms. Together ILT and DST provide the basis of a theory that is capable of explaining cultural phenomena and cultural evolution from the perspective of information transmission. The theory that I have synthesised is referred to as the Complex-Systems Theory of Culture (CSTC).

CSTC provides an understanding of the structure and function of individual cultural entities, and it provides an understanding of how cultural entities vary and change. As complex systems of information transmission cultural entities display continuity through the unchanging and relatively simple mechanism of information flow. Information flow is also the fundamental mechanism that results in discontinuous changes in the structures that we identify as cultural entities. This means that all aspects of culture can be investigated from one perspective – information flow. This universal perspective not only promises to simplify archaeological research, but it also provides a perspective for making all aspects of cultural phenomena comparable to each other. In other words, the adoption of a theory, such as CSTC, will eliminate the discontinuity of research in archaeology that has kept the investigation of each region and era isolated each other by providing a universal common mechanism that will allow a meaningful integration of all archaeological research.

Some of the foremost issues of archaeological research involve the reconstruction of social organisation, symbolic ritual, power structures, craft specialisation, trade relationships, and subsistence strategies. It is the contention of this research that all of these can be reconstructed and investigated using CSTC. To demonstrate this conviction CSTC was used in chapter 7 to analyse the social organisation of the Natufian site of Mallaha. Information flow is the key to diversity within and between cultural entities. As information flow to all individuals increases (becomes more homogeneous) cultural diversity decreases, but if information flow to all individuals decreases (becomes more heterogeneous) cultural diversity increases and cultural forms become more diverse. All aspects of behaviour at the Natufian site of Mallaha either varied randomly or were very similar and uniform across the excavated portions of the site. Two main conclusions are indicated in Chapter 7. First, Natufian burial behaviour displays no discernable evidence of being a ritual or symbolic behaviour because all aspects of the burials vary randomly. Second, none of the data at Mallaha displays any signs of a structured social organisation because the information displayed across the site is uniformly similar. This means that the social organisation of Mallaha is relatively simple (unstructured) and represents the near equilibrium condition that probably characterises the social organisation of all our hunter-gatherer ancestors up to the Natufian.

Chapter 8 is an extension of Chapter 7 in that it employs a diachronic perspective that is inherent to CSTC to demonstrate that Natufian burials are neither ritual nor symbolic, but that burials begin to display symbolic aspects in the PPNA, which are continued and elaborated in the PPNB. The PPNA data from Nativ Hagdud demonstrates that the social organisation of cultural entities is beginning to become structured in ways that are significant enough to be discerned in the material culture. This view is reinforced by the data from the PPNB that demonstrates that multiple structures may exist in the social organisation of the groups of this era. This analysis demonstrates that CSTC can be used to identify and investigate social organisation in the archaeological record.

9.2 SOCIAL COMPLEXITY

Social complexity is a difficult issue to investigate using archaeological data, but a theory such as CSTC provides the means for gaining some knowledge about this topic. The Natufian displays no evidence of a structured social organisation. Does this mean that there was absolutely no structure to the social organisation at Mallaha? Definitely not! What this does mean is that the social organisation that was present was close to the equilibrium condition, which does represent the completely unstructured condition. In other words, the social organisation in the Natufian may be weakly or loosely structured, but the structure does not result in patterns of information differentiation that can be discerned in the material products of Natufian behaviour.

One other consideration is that this research has avoided engaging the chipped stone data (largely due to time constraints and my lack of technical expertise), and the chipped stone industry is probably the best source of data for detecting structure in social organisation (this will be discussed in more detail later). It is still quite possible that a more intensive or extensive analysis of all the Natufian data could detect some indications of structured social organisation. On the other hand, this first cursory analysis establishes that the Natufian does not have the complex social organisation that is typically attributed to farming villages. In fact any social structures that may be detected in the Natufian will be much weaker than the one that is discussed for the PPNA. It is significant that CSTC can be used to identify structured social organisation in the burial practices of the PPNA, and that this structure is continued and elaborated in the PPNB.

9.3 ORIGINS OF AGRICULTURE

The Origins Of Agriculture in the Near East was chosen as a time frame for this research because DST is particularly useful as a tool for understanding transformations within complex systems especially the appearance of unique and unexpected behaviour. The direct evidence for subsistence, and the possible behaviour that lead to agriculture, is almost non-existent at sites from the Upper Palaeolithic through the Natufian, which represents the focus of this research. None-the-less, CSTC can provide some insight into the questions surrounding the origins of agriculture. Why does agriculture appear when it does? Why does it not occur earlier in human history? There do not appear to be any good environmental answers to these questions. Climate seems to have been amenable to agricultural activities at several earlier times in the past. Also, many plants and animals are conducive to human manipulation so there appears to have been no shortage of potential domesticates at earlier times. CSTC does provide a possible "cultural" answer to this conundrum.

The Upper Palaeolithic is dominated by behaviour that is based on extractive and reductive strategies. On the other hand, some constructive strategies are evident in the Upper Palaeolithic – hafting tools and constructing simple shelters are two examples. The data indicates that constructive strategies increase until the Natufian displays elaborate dwellings, the PPNA displays two levels of constructive behaviour in its dwellings (constructing mud bricks to be used to construct dwellings), and the PPNB displays a number of elaborate plaster construction strategies that seem to pervade every aspect of life. From this perspective the advent of agriculture seems to be the logical result of a changing worldview that stresses the advantages of constructive strategies. This may seem to be an unsatisfactory explanation, but faced with the fact that many plants and animals can be used in a food production strategy there seems to be no other explanation why agriculture is not attained before 20 kya but agriculture seems to be independently invented in many places in the world after

20 kya. CSTC provides a perspective that demonstrates that cultural innovation is not dependent on increased cognitive or intellectual capacities. Cultural innovation is dependent on increasing the knowledge content of the group. In other words, the knowledge content of the cultural entity acts as an absolute constraint on the behaviour of the group.

CSTC provides another insight into agricultural systems. Agriculture is more of a designed system than it is an evolved system. Evolved systems are very complex, but their complexity results in an increase in stability due to their inherent self-organised nature. On the other hand, complex designed systems tend to be unstable and susceptible to catastrophic failures. This indicates that early agricultural communities should display some indications of instability. I have not dealt with this aspect of agriculture because it seems to be something that would be relevant to research in the PPNC or later, which is beyond the scope of this research.

There is very little that this research can demonstrate about the origins of agriculture. The data from the Near East is virtually nonexistent, and the CSTC is not adequately devolved at this time. On the other hand, it seems obvious that a theoretical perspective, such as is provided by CSTC, could be an extremely useful tool for advancing our general understanding of the origins of food producing strategies.

9.4 CYCLIC NATURE OF CULTURAL SYSTEMS

CSTC provides insight into a similar question that I find intriguing. Why is it that the Natufians seem to be the first to place camps consistently at locations that are highly productive centres for subsistence resources? Earlier peoples may not have noticed these places, earlier peoples may not have been able to utilise these resources, or these places didn't exist (in their highly productive form) before the Natufian. Evidence from sites such as Ohalo II allows us to discard the first two possibilities and focus on the third.

CSTC states that very small changes can become part of a positive feedback loop that magnifies them until they transform the system. This suggests that small changes in human behaviour could become involved in a process of landscape modification that is completely unintentional, but that could result in a transformation of the landscape and the human interaction with the landscape.

In the Upper Palaeolithic a substantial amount of evidence establishes the existence of weaving technology that produced such items as baskets, nets, and fibre sacks. These tools could have been used to transport significant quantities of cereal grain, seeds, and nuts around the landscape, possibly for the first time in human history. The transportation of seeds and nuts also means the spilling and discarding of seeds and nuts – possibly outside of their normal home range. Over many hundreds of years some campsites that were visited repeatedly for their original natural resources could have become transformed with additional resources that were introduced unintentionally. This could produce a positive feedback mechanism that draws groups to specific sites more often, which increases the rate of alteration of the landscape until the Natufian phenomenon seems to crystallise into a completely new behaviour. This process might also explain how people learned the relationship between seeds and nuts, and the plants that grow from them.

9.5 CHIPPED STONE TECHNOLOGY

CSTC is in the very first stages of being developed, and it is fundamentally a conceptual theory. None-the-less, even at this stage CSTC promises to be a useful tool, and I will explore this potential by discussing the application of CSTC to lithic data. I have avoided a comprehensive discussion of lithics in the body of this research for a number of reasons. The foremost is that lithic technology during the era that is the focus of this research has probably reached its most complex form. This means that new forms of lithic production are still possible, but the complexity of production techniques had probably approached a maximum.

By the Natufian lithic technology encompasses such a large number of techniques and possible combinations of techniques that it cannot be addressed in a meaningful way by a rank amateur such as myself. In other words, the application of CSTC to lithic production will require technicians who understand the principles of CSTC and who have an expertise in reconstructing the techniques involved in lithic production. None-the-less, CSTC can be used to generate a testable hypothesis about the use of lithic data in archaeological research.

My understanding of lithics as a complex behaviour allows the following hypothesis to be generated by CSTC. Lithic production is a complex behaviour with many techniques that can be employed in many different combinations to produce very similar end products. Also, a very limited number of techniques can be employed to produce a large number of end products. This means that the consistent use of a specific set of techniques in lithic production can only result from being constrained as part of a cultural entity. From the CSTC perspective this means that an analysis of production techniques could allow researchers to reconstruct patterns of regional interaction between sites, relative levels of interaction within and between sites, and relationships of cultural descent within and between sites.

This is not going to be an easy task, and it will require dedicated lithic investigators who understand CSTC. It will also require the development of a formal system for investigating the information content evident in lithic production. This endeavour will also require a fundamental change in field methodology. Lithic debitage has become one of the aspects of data collection that is typically discarded so that more resources can be used to investigate more "important" aspects of pre-historic behaviour (such as subsistence, burials, and architecture). From the CSTC perspective debitage (and its context) is the data that has the best chance of allowing us to reconstruct social relationships and possibly even personal behaviour in prehistory.

One attempt has been made to reconstruct cultural relationships between two distinct regions. The Bradley-Stafford model discussed in Chapter 7 (see Figure 7.21) used the comparison of production techniques and sequences to demonstrate that the Clovis point in North America is nearly identical to the Solutrean blade industry from Europe. This is the first example, which I am aware of, of a discussion of three lithic assemblages that doesn't focus on blades, cores, or flakes. The Bradley-Stafford model engages a complex technology from the perspective of information and behaviour and not typological objects. The Bradley-Stafford model is a paradigm, but CSTC explains why this model probably does indicate that the Clovis technology shares a close ancestral relationship with the Solutrean technology.

This type of approach is proposed by Quintero (1997), and was discussed towards the end of Chapter 8. The limitations of Quintero's analysis are due to the fact that it is a paradigm-based methodology, which means that it is directly based on high-level assumptions and arguments instead of explanations. On the other hand, Quintero's (1997) analysis of the lithic data at 'Ain Ghazal demonstrates that some researchers are attempting to achieve a more sophisticated use of lithic data, which a theory such as CSTC could facilitate.

9.6 THE ADVANTAGES OF THEORY

Throughout this thesis I have stressed the advantages of the theory methodology over the paradigm methodology. This obvious bias is not due to a personal belief that the paradigm methodology is wrong or that it should be abandoned. On the contrary, the paradigm methodology is indispensable, and it does have attributes that many researchers will find preferable to the theory methodology. I am advocating that we need to include the theory methodology in archaeological research. For this reason I have focused on the advantages of the theory methodology in an attempt to justify the effort that is required to employ it in archaeological research.

I will take this last opportunity to reiterate the necessity for a theory-based methodology (such as is provided by CSTC). First, interpretations that are based on a theory are repeatable and testable. This is due to the fact that theories explain phenomena based on the objective perspective of the mechanisms that are inherent to the phenomena. Second, all aspects of archaeological data provide comparable interpretations when they are based on a theory. Finally, theory provides the insight to formulate appropriate data collection. If archaeological research is to realise its potential for extracting knowledge from its data then we need both the paradigm methodology and the theory methodology.

APPENDIX A

A General Systems Model of the Origin of Agriculture

In *The Rise of Civilization* Charles Redman (1978) provides a closed system model for understanding the origin of agriculture. This model provides an excellent example of how complicated general systems models can become even when they are still so simplified that they do not adequately represent the interactions inherent in the process being discussed. Redman suggests that this model provides a framework for investigating and evaluating current hypotheses and archaeological evidence. On the other hand, I maintain that this model is too simplistic to actually represent the process involved in a subsistence transformation to agriculture, and at the same time this model is too complicated to be useful.

Figure A-1 provides a block diagram that represents Redman's model, and Figure A-2 provides a list of factors that affect the introduction of agriculture in this model. One indication of the simplistic nature of this model is found in the way Redman has paired agriculture with sedentism to produce only two paths that lead from hunting-gathering to agriculture (transition 3 and 7, or transition 5, 9, and 11).

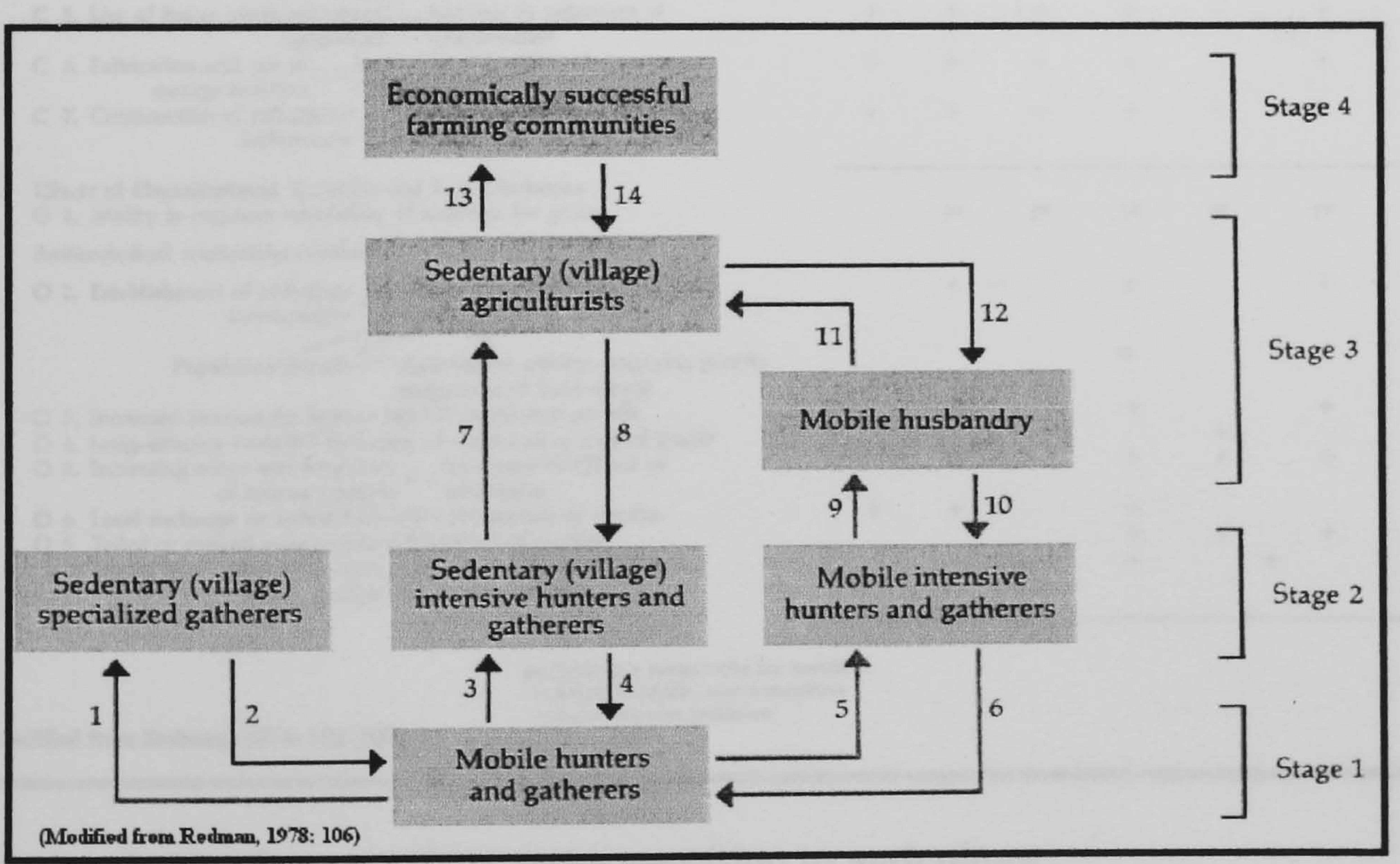

Figure A-1: A block diagram representing the paths for the transition to agriculture.

Factor	1	2	3	4	5	6	7	8	9	10	11	12	13	14
A. Barriers to the Introduction of Agriculture														
B 1. Annual fluctuations in climate (increase in lean periods)				+			–			+	–	+	–	
B 2. Extreme localization of dense cereal stands	+						–				–			
B 3. Brittle rachis of wild wheat and barley					–		–				–			
B 4. Tough glumes of wild grain							–						–	
B 5. Necessity for harvesting tools, containers, and transport					–		–							
B 6. Necessity for waterproof storage facilities							–							
B 7. Either migratory or mountain-adapted habitats of hunted animals							–		+		–			
B 8. Ability to induce animals to change seasonal routine							–				–			
B 9. Interpersonal stress of larger agricultural communities							–				–			
B. Effects of Environmental Factors														
E 1. Availability of potentially domestic plants and animals			+		+		+		–		+			
E 2. Ecological uniformity in vicinity	+				+				–					
E 3. Ecological diversity in vicinity (including wild grain, sheep, and goats)			+				+				+			
E 4. Climatic change that improved conditions for domesticable plants			+				+				+			
E 5. Climatic change that worsened conditions for domesticable plants				+				+		+		+		+
E 6. Climatic change that produced temperate conditions allowing open settlements	+		+				+				+			
Positive-feedback relationship established with agriculture														
E 7. Culturally altered environment: Increasing land clearance for agriculture ⇄ diminishing resources for hunting and gathering							+	–					+	–
C. Effects of Subsistence Strategies														
S 1. Dependence on migratory herd animals					+				+					
S 2. Dependence on nonmigratory animals	+		+				+							
S 3. Dependence on tree nuts (autumn harvest)	+		+				+							
S 4. Dependence on cereal grasses (spring harvest)			+				+							
S 5. Dependence on combination of plants and animals			+				+							
Positive-feedback relationship established with agriculture														
S 6. Selective killing of young male animals ⇄ Maintain herd size	+		+		+		+		+		+			
S 7. Field stubble eaten by animals ⇄ Fields manured by animals							+				+		+	
S 8. Increasing productivity of grain ⇄ Denser stands of grain			+				+				+			
S 9. Transfer of plants into new environmental zones ⇄ Selection for hardier strains and increased hybridization							+		+		+		+	
S 10. Abandonment of other activities during planting and harvesting ⇄ Increased agricultural yield							+	–	+	–	+		+	
S 11. Transfer of settlement to location near agricultural activities ⇄ Diminishing importance of hunting and gathering							+						+	
S 12. Increased production of food ⇄ Increased population growth			+				+				+		+	
D. Effects of Cultural Innovations														
C 1. Microlithic composite tools			+		+									
C 2. Understanding environmental potential	+		pr		+		pr		pr		pr		pr	
Positive-feedback relationship established with agriculture														
C 3. Investment in inventory of specialized harvesting tools or techniques ⇄ Greater yield per hour of harvesting	+		+		+		pr		pr		pr		pr	
C 4. Investment in inventory of food, processing equipment, and techniques ⇄ Greater nourishment per kilogram harvested	+		+		–		+		–		+		+	
C 5. Use of heavy plant-processing equipment ⇄ Increase in sedentism of communities	+		+				+		–		+		+	
C 6. Fabrication and use of storage facilities ⇄ Increase in sedentism of communities	+		+		–		+		–		+		+	
C 7. Construction of substantial architecture ⇄ Increase in sedentism of communities	+		+				+		–		+		+	
E. Effects of Organizational Variables and Social Relations														
O 1. Ability to organize scheduling of activities for group			pr		pr		pr		pr		pr		pr	
Positive-feedback relationships established with agriculture														
O 2. Establishment of sedentary communities ⇄ Young and elderly allowed to live and work; Population growth ⇄ Agricultural activity supplying greater proportion of food supply			+	–			+				+	–	+	
O 3. Increased concern for human life ⇄ Population growth			+				+				+			
O 4. Long-distance trade ⇄ Exchange of ideas and species of plants					+				+				+	
O 5. Increasing scope and frequency of human contacts ⇄ Increased likelihood of innovation							+		+		+		+	
O 6. Local exchange or redistribution ⇄ Production of surplus			+				+						+	
O 7. Tribal or ranked organization ⇄ Control of surplus							+		+		+		+	
O 8. Spatial impingement by other groups ⇄ Clearer delineation of a group's territory		–					+			+		+		

pr: factor is a prerequisite for transition
+: factor favorable, affects transition
–: factor impedes transition

(Modified from Redman, 1978: 108-109)

Figure A-2: The factors affecting the transition to agriculture.

A review of research on agriculture from around the world demonstrates that there exists any number of paths to agriculture, and that not all of them involve sedentary life styles.

Figure A-2 demonstrates how this model is too complicated to be useful. Redman's list of factors that affect the introduction of agriculture is so large that it is not possible to follow them all or to combine them to see what the results could be. This places a researcher in the position of having to pick which factors seem to be the important ones, and using only those. This is a typical problem with models that are constructed within a paradigm methodology, and it means that each researcher will probably pick a unique set of factors. This results in a unique conclusion for each researcher.

This is a typical example of a model that is built on a paradigm. It is a complicated argument about a phenomenon (the origins of agriculture), but ultimately it does not explain the phenomenon, nor does it result in repeatable or testable propositions.

APPENDIX B

Population Size And Subsistence Labour

This is a demonstration of the normal movement of populations from low productive zones to high productive zones. This demonstration is based on the construction of four hypothetical subsistence productive zones. Figure 1 represents the base line for this example, and as it is the lowest productive zone of the four it is designated the marginal zone. In this marginal zone a group of 10 people can provide their subsistence in a region that extends no farther than a one hour walk from their camp and can be accomplished by expending an average of 2 hours of labour per person each day. The increase in labour required to provide for subsistence as group population grows is based on the increased distance that must be travelled as the surface area utilised expands proportionally to population. In other words if you double the population the surface area utilised will also double.

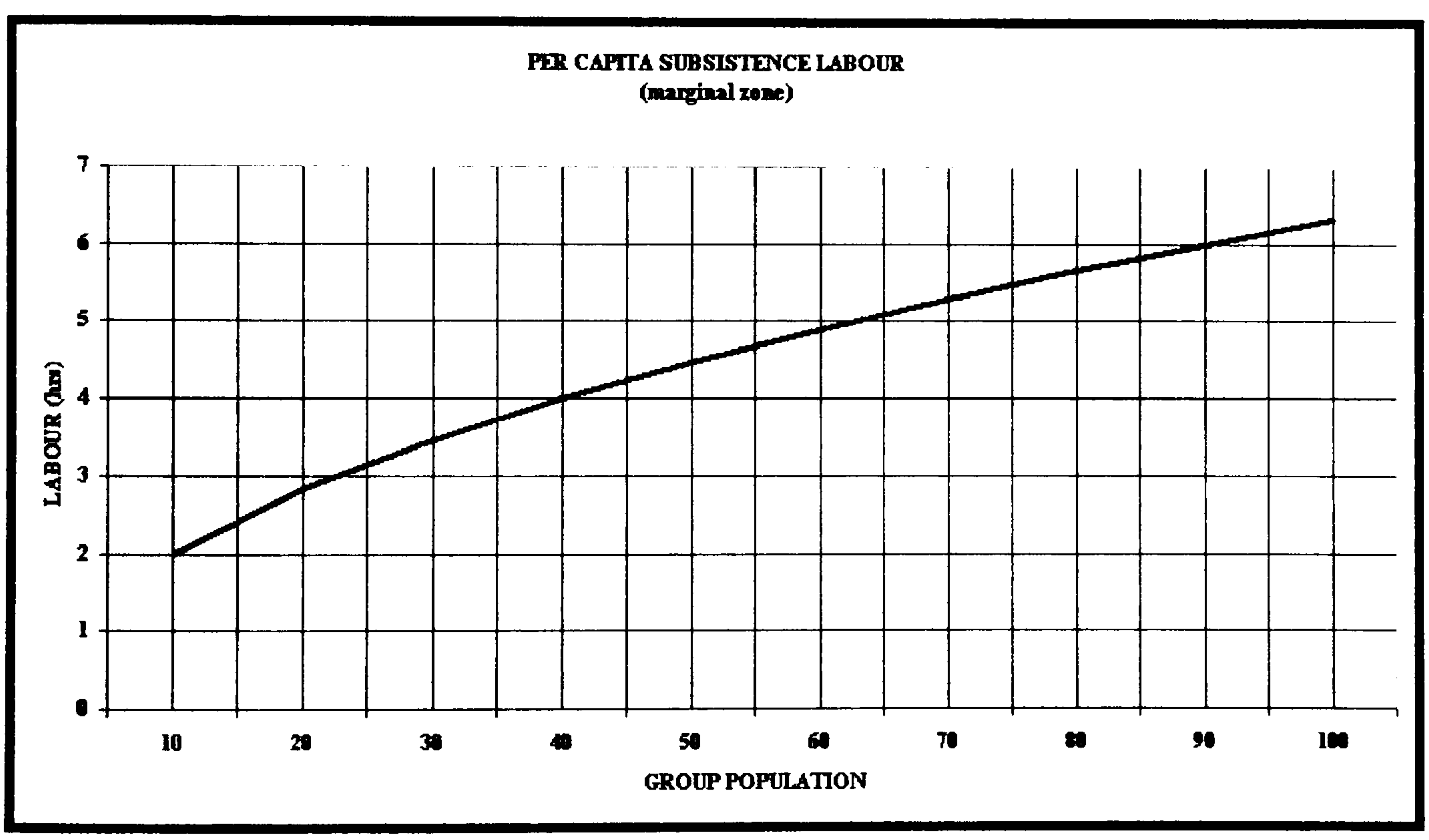

Figure B-1: Daily Per Capita Subsistence Labour Based On Population Levels In A Marginal Zone.

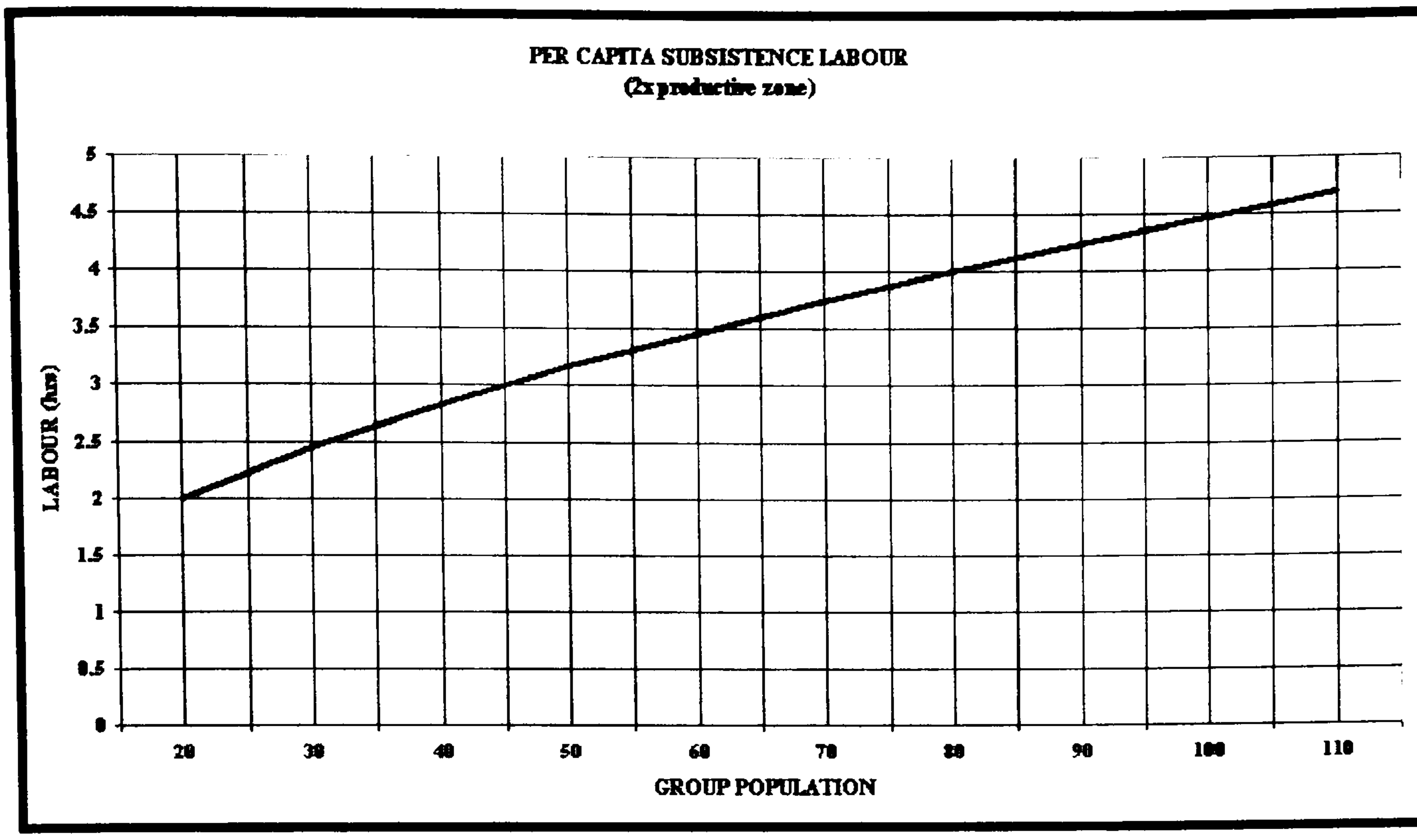

Figure B-2: Daily Per Capita Subsistence Labour Based On Population Levels In A 2x Productive Zone.

Case Number One

In this example the marginal zone is located next to a productive zone that can sustain twice the population per unit area. This is evident in that the per capita labour of 4.0 hours is reached at a population of 40 in the marginal zone and a population of 80 in the productive (2x) zone. It is at this level of equivalent labour that adjacent zones of productivity should reach a level of relative stability. In other words, there are twice as many people in the productive zone, but there is no motivation to move to the lower population areas of the marginal zone. In either zone it will take an average of 4 hours of labour to provide subsistence.

The first example is what would happen if 10 people moved from the productive zone to the marginal zone. The population in the productive zone would decrease from 80 to 70 and the per capita labour would decrease from 4.0 to 3.74. This would result in a per capita saving of 0.26 hours. The population in the marginal zone would increase from 40 to 50, and the per capita labour would increase from 4.0 to 4.47 hours. Not only does the population of the marginal zone experience a significant increase in per capita labour, but also the total labour of the combined populations increases from 480 to 485.5 hours per day.

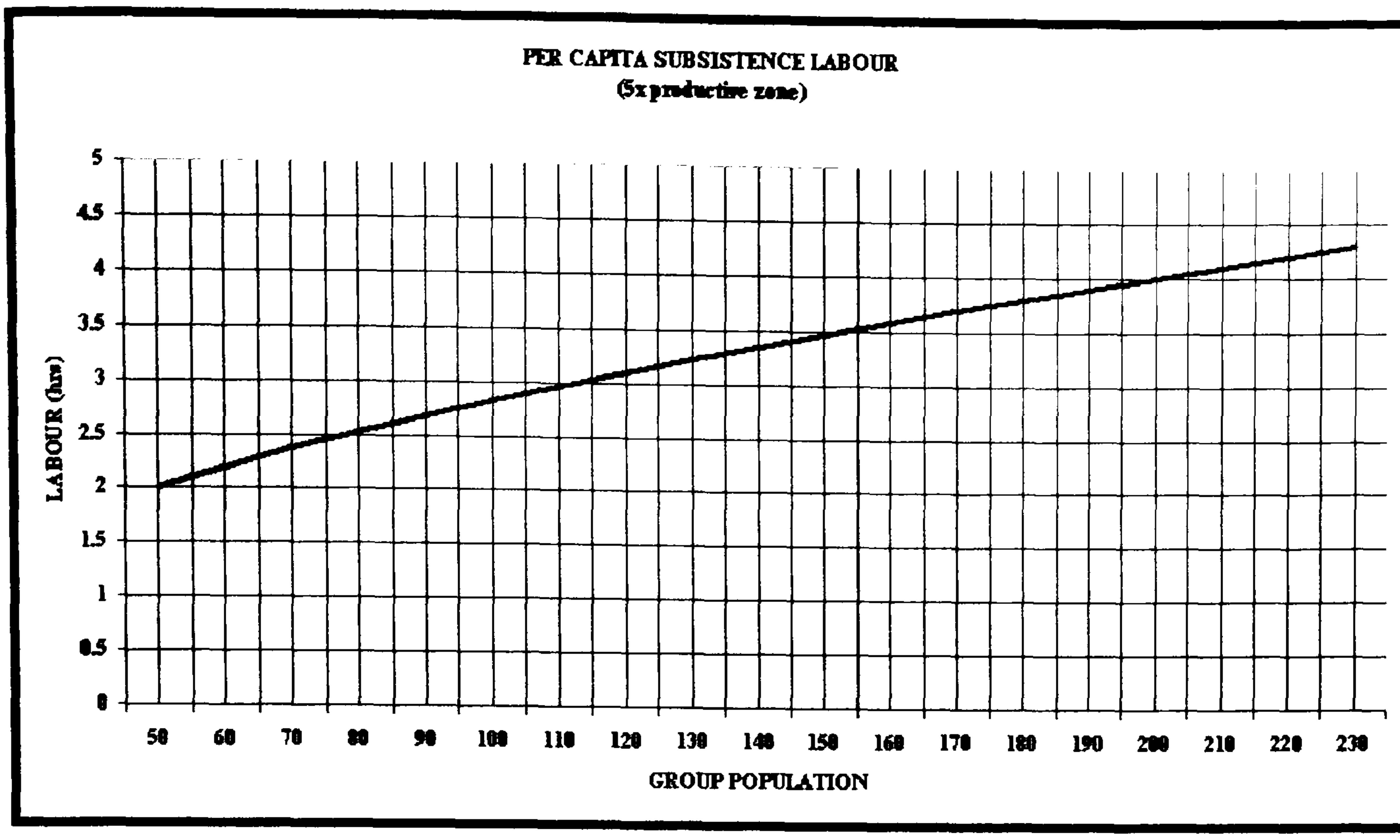

Figure B-3: Daily Per Capita Subsistence Labour Based On Population Levels In A 5x Productive Zone.

Case Number Two

In this example the marginal zone is adjacent to the productive (5x) zone. If the populations reach equilibrium at 4.0 hours of subsistence labour per capita then the marginal zone population will be 40 and the productive zone will be 200. If 10 people move from the productive zone to the marginal zone the per capita labour will decrease from 4.0 to 3.9 hours in the productive zone. In the marginal zone the per capita labour will increase from 4.0 to 4.47 hours. The total labour of the combined populations increases from 960 to 964.3 hours per day.

Case Number Three

In this example the marginal zone is adjacent to the productive (10x) zone. It will be assumed that the populations reach equilibrium at 4.0 hours of per capita subsistence labour. The marginal zone population will be 40 and the productive zone population will be 400. This time 10 people will move from the marginal zone to the productive zone, and the per capita labour will decrease from 4.0 to 3.47 in the marginal zone. The population in the productive zone will increase from 400 to 410 and the per capita labour will increase from 4.0 to 4.05 hours. The total labour of the combined populations will increase from 1760 to 1764.17.

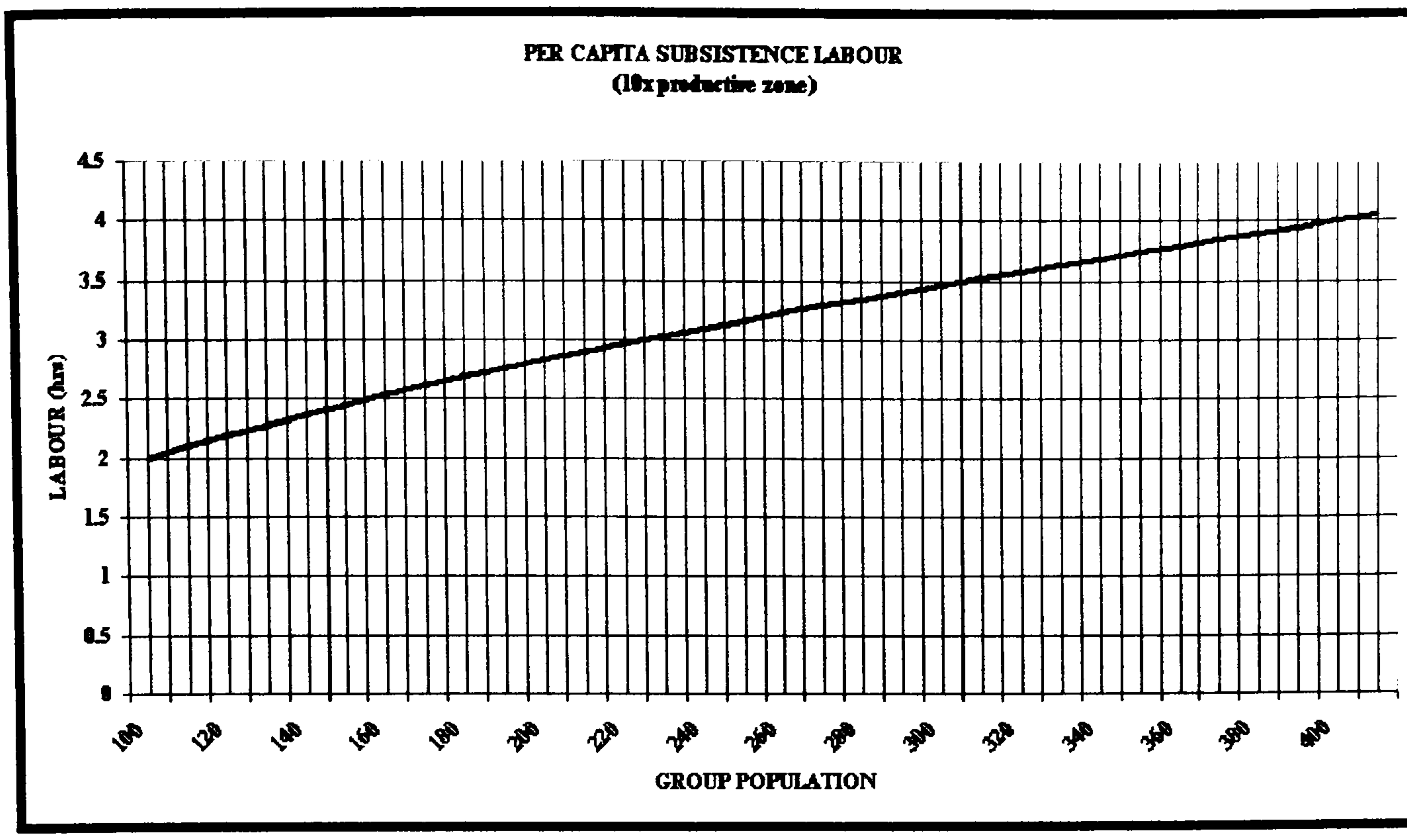

Figure B-4: Daily Per Capita Subsistence Labour Based On Population Levels In A 10x Productive Zone.

Implications Of This Example

1. Adjacent populations will tend to stabilise at an equilibrium that represents equivalent levels of subsistence labour.
2. Any movement of populations from one zone to the other during the equilibrium regime will result in an increase in labour to the group that experiences an increase in population.
3. Any movement of populations from one zone to the other during the equilibrium regime will result in an increase in labour to the combined population.
4. Populations would be more likely to move from the marginal zone to the productive zone. This is evident in that the increases to per capita labour in the productive zone are relatively small compared to the decrease in labour produced in the marginal zone.
5. As the differential in productivity between the two zones increases the motivation to move from the marginal zone to the productive zone increases. (You could save your friends or kin in the marginal zone over half an hour of daily subsistence labour per capita by moving your 10 kin to the productive zone, and if it is the 10x productive zone it only costs you 0.05 hours of daily subsistence labour per capita).

This exercise demonstrates that population density is not as relevant as the productivity of a zone of residence. In other words, it is more likely that low productive zones will donate people to high productive zones if the populations are at or near equivalent labour expenditures for subsistence even though the productive zone has a much higher population density.

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