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ELEMENTARY SCIENCE STUDENTS' CONCEPTIONS IN BIOLOGY: THEIR LANGUAGE, MEANINGS, CLASSIFICATIONS, AND INTERPRETATIONS OF SCIENCE CONCEPTS: AN ETHNOGRAPHIC STUDY

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Abstract

ELEMENTARY SCIENCE STUDENTS' CONCEPTIONS IN BIOLOGY: THEIR LANGUAGE, MEANINGS, CLASSIFICATIONS, AND INTERPRETATIONS OF SCIENTIFIC CONCEPTS: AN ETHNOGRAPHIC STUDY

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An ethnographic study was conducted with the goal of examining the botanical knowledge of nine sixth grade students. The language, meanings, classifications, and interpretations of botanical concepts presented by the students were compared to those found in the elementary textbook series, Science, by Silver Burdett, 1985.

Several aspects of children's botanical knowledge were examined: children's names for plants, the level of abstraction that was psychologically basic in naming plants, categories for plants, names and functions for plant parts, and children's explanations for abstract concepts, such as photosynthesis, reproduction, the importance of plants to humans, and differences between plant and animal, living and non-living.

Many of the scientific terms found in the elementary textbooks were either not used or were poorly understood by the children. The children did use many of the folk botanical terms and categories that adult laymen would use. The children's knowledge in these areas was not naive or idiosyncratic, rather it was based on folk cultural knowledge. When children did not know names for plants they used a variety of strategies to avoid admitting ignorance or being wrong.

The children selected members for plant categories based on similarity to a prototype. They gave rich descriptions of plants and showed abilities to recognize plants at the generic and family level. They showed a preference for naming plants at the generic level of abstraction (e.g., oak) rather than at more abstract levels (e.g., tree). The elementary textbooks introduced abstract levels of the scientific classification scheme (e.g., monocot, dicot) and did not discuss the concepts of family, genus, and species.

The children's explanations for abstract botanical phenomena were poor and somewhat idiosyncratic, based partly on text-taught information and partly on folk cultural knowledge. The textbooks often did not provide enough information to bridge the gap between the child's knowledge and the scientist's knowledge. Many botanical terms were not adequately defined and some statements in the text were false or misleading. The textbooks did not promote the stated goals for science education put forward by various educational organizations.

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CHAPTER I - INTRODUCTION

Research in education has demonstrated that children come to school with a body of knowledge about the world around them. From the early studies of Piaget (1929) to the many studies of the past decade (see Carey, 1985; Helm & Novak, 1983; Osborne & Wittrock, 1983) researchers have examined children's explanations of natural phenomena.

Ausubel has asserted that the conceptions children bring with them to the classroom strongly influence what they subsequently learn (Ausubel, Novak, & Hanesian, 1978). Hills (1983, p. 268) has suggested that the child's interpretations differ from that of the scientist because the child is working within a different theoretical framework. Linn (1987, p. 197) has stated that recent research suggests students do not simply absorb knowledge, rather they "constantly interpret new information based on their particular world view." New information introduced during the school years must, therefore, take into account the conceptual framework of the child.

In the field of science education, a large number of studies have been conducted on children's misconceptions in science. Research on misconceptions has focused on abstract science concepts and has tended to emphasize children's lack of knowledge. Because of the limited applicability of such research, I have chosen to approach the study of children's conceptions in science from the point of view of cognitive anthropology. Cognitive anthropologists study cultural knowledge by examining language and its meanings.

The current study was designed to evaluate the interpretations of botanical concepts of sixth grade students in central Texas. I documented the child's language, meanings, classifications, and concepts concerning the world of plants. I wanted to determine the extent to which the students' conceptual framework resembles either that of the scientist or that of the adult layman. The botanical concepts presented in the elementary textbook series *Silver Burdett Science*, 1985, were also examined as a point of comparison.

Background

The National Assessments of Educational Progress (Mullis & Jenkins, 1988; NAEP, 1978, 1979a & b) and other recent studies have shown a nationwide decline in student achievement in science. This decline has caused great concern among science educators and is the impetus behind much current research in education.

Both research on children's conceptions in science and research on cognitive abilities at different

ages provide valuable sources of information to assist curriculum writers. Based on that body of research, the National Science Teachers Association (NSTA) and the American Association for the Advancement of Science (AAAS) have published recommended guidelines concerning the science concepts and science skills to incorporate into school curricula (see AAAS, 1989; NSTA, 1982a & b).

Project Synthesis (a synthesis of several evaluative studies on children's progress in science) reported that more than 90% of 12,000 teachers surveyed rely on the science textbook for their science curriculum 90-95% of the time. Clearly, "the curriculum is the textbook, and the objectives are those implicit in the text" (Harms & Yager, 1981, p. 20).

If student performance in science has deteriorated, and if teachers rely on the text for virtually all of their curriculum, then the influence of the textbook cannot be overlooked when evaluating students' knowledge.

To that end, this study combined two approaches, evaluation of children's interpretations of botanical concepts and evaluation of textbook interpretations of botanical concepts. It was hoped that a comparison and contrast between these two bodies of knowledge would shed some light on the problem of low student achievement in science.

Rationale and Theoretical Framework

"The most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly." - David P. Ausubel (Ausubel, Novak, & Hanesian, 1978, p. iv.)

The child does not come to school as a *tabula rasa*, a clean slate. From kindergarten through college, the student brings to the science classroom a database of knowledge developed from daily experiences, observations, and readings, in school and out of school (Osborne & Wittrock, 1983). The child's earliest concepts are formed from first hand experience, "through successive stages of hypothesis generation and testing and generalization" (Ausubel, Novak, & Hanesian, 1978, p. 56).

Successful curricula will be based on the foundation of knowledge that the child brings to the classroom. All the child's knowledge related to a topic, whether "right" or "wrong", can have an influence on the child's acceptance of new concepts. Research focusing on misconceptions may overemphasize what children do not know, while overlooking what they do know. To assist children in bridging the gaps between their conceptual frameworks and the conceptual framework of the scientist we need to take a close look at children's knowledge in science.

"Science is not just a collection of laws, a catalogue of facts, it is a creation of the human mind with its freely invented ideas and concepts." - Albert Einstein and L. Infeld (1938).

Einstein and Infeld have captured the idea that observation alone does not determine scientific theory. Theories are constructions, creative inventions. Scientists and children both interpret what

they observe. Hills (1983, p. 266) stated that "perception is influenced by the concepts, beliefs, expectations, and prior knowledge of the observer. Hence, confronted with the same phenomena... adherents of different theories will observe different things."

Hills suggested that the child works within a framework that differs qualitatively from the scientific framework. He called that framework the commonsense framework. Osborne and Wittrock (1983) stated that learning science often requires "the restructuring of existing ideas so that pupils view things from a different model, rather than adding the new information to existing knowledge" (p. 500).

Science educators have expressed concern about the difficulty teachers have in replacing the child's misconceptions with scientifically acceptable interpretations of natural phenomena. Misconceptions can block the assimilation of new knowledge or result in a distortion of the new information in an attempt to reconcile it with the old. Students may hold tenaciously to their misconceptions (Arnaudin & Mintzes, 1985; Ausubel et al., 1978; Trembath, 1980).

Although Piaget and his associates conducted much valuable research on the conceptions of the young child, much recent research has focused, not on the child's interpretation of the observable world, but on the child's misconceptions about abstract scientific concepts. More information is needed on the elementary child's notions about the observable world as well as about abstract concepts. The formation of early concepts related to objects the child can see and touch form the building blocks upon which the understanding of abstract concepts, such as photosynthesis and reproduction, will be built.

Purpose of the Study

This was a two-part study. Using ethnographic interviews, I first examined the sixth grade student's interpretations for botanical concepts. Secondly, I examined the botanical concepts introduced in the elementary textbook series used by the students, *Silver Burdett Science*, 1985.

People present their knowledge through language. To examine the conceptions of a group of people, one must examine the language used by that group of people and the meanings for that language.

Kempton (1981) called the sum total of the idiosyncratic meanings in a culture the folk knowledge of that culture. The current study attempted to document the idiosyncratic botanical language, meanings, classifications, and interpretations of concepts of nine sixth grade children. From those idiosyncratic meanings, I hoped to develop theories concerning the summative folk botanical knowledge of sixth grade children in central Texas.

I compared and contrasted the language, meanings, classifications, and interpretations of botanical concepts as presented by the students and the textbook. Both bodies of knowledge were evaluated in relationship to the body of knowledge of botanists and adult laymen. It was hoped that such a comparison would enable me to (1) discover both the strengths and the

weaknesses in the child's botanical knowledge; (2) evaluate the extent to which the child's botanical knowledge resembles that of the science text, the scientist, and the adult layman; (3) discover the manner in which the child has organized his or her knowledge of plants; (4) evaluate the extent to which the botany related text reflects the recommendations for science education proposed by the NSTA and the AAAS; and (5) evaluate the extent to which the textbook has bridged the gap between the conceptual frameworks of the child and the scientist.

Considerable research has been conducted on student misconceptions concerning highly abstract botanical concepts (e.g., photosynthesis). But little research has been conducted on the elementary child's knowledge of plants, particularly the child's meanings for concrete concepts (e.g., the child's meanings for the terms *leaf* or *tree*).

The current research attempted to fill in some of these gaps in the research, providing a baseline of information about children's botanical knowledge just prior to entering seventh grade life science. I hoped to produce a body of data relevant to the preparation of life science and elementary science curricula. In addition, it was hoped that data on children's names and classifications for plants would add to the body of knowledge in cognitive anthropology concerning what type of botanical knowledge is significant to people and how people organize that knowledge in their minds.

Objectives Investigated

I examined the child's and the textbook's interpretations of botanical concepts. Novak, Gowin, and Johansen (1983) defined *concept* as "a perceived regularity in events or objects designated by an arbitrary label" (p. 625). A concept may represent a set of tangible objects such as trees or an abstract theory such as photosynthesis. Even when representing tangible objects, however, a concept is of necessity an abstraction, a generalization.

Lowery (1981) considers concepts "classifications of stimuli that have one or more common characteristics or attributes" (p. 75). Concept formation depends on the ability to classify objects or ideas into groups. To study the child's interpretation of concepts, therefore, I examined the child's language, meanings, and classifications relating to the world of plants.

The research was designed to address the following questions. What terms does the child use when talking about plants (language)? What objects and ideas go with those terms (meanings)? How does the child organize his or her botanical knowledge (classification)? How does the child interpret botanical phenomena (scientific concepts)? How does the conceptual framework of the child compare with that of the elementary science text, botanists, and adult laymen? How well does the text bridge the gap between the conceptual models of the child and the scientist?

In order to address these broad questions, the following specific questions were examined:

1. Names for plants: What are the children's names for plants? What types of plant names do children remember? When children do not know names for plants, how do they respond?

2. Basic level of abstraction: What level of abstraction is psychologically basic for naming plants?

3. Categories for plants: What major categories does the child use to classify plants? How does the child define those categories?

4. Hierarchical relationships for plants: How do the child's plant categories relate to each other hierarchically?

5. Names for parts of plants: What terms does the child use in describing plants? What objects do those terms signify in the mind of the child?

6. Abstract concepts: What is the child's explanation for various abstract botanical phenomena (e.g., the function of leaves and flowers and other plant parts; the environmental needs of plants; the differences between plants and animals, living and non-living; the importance of plants to humans)?

7. How are the botanical concepts presented in the elementary science textbooks?

Research Design

This is an ethnographic study. Ethnography has different goals from quantitative research. Rather than starting with stated hypotheses, the researcher attempts to describe conditions observed in a culture. In the process, the researcher may discover hypotheses worthy of further investigation. The researcher begins with some questions of interest and the data itself generates more questions. Some questions are examined within the research (Kirk & Miller, 1986) and some provide the basis for later studies.

The goal of ethnography is to make the informant's tacit knowledge explicit. Though informed by specific questions of interest, an ethnographic study is generative and inductive in nature. From a body of empirical observations, the researcher builds "theoretical categories and propositions from relationships discovered among the data" (Goetz & LeCompte, 1981, p. 51). Thus ethnography is interpretive in nature.

The written tests relied on so often by researchers (often a necessity due to lack of time and resources for a more thorough study) greatly limit the amount of data that a single study can provide. Novak and Gowin (1984) have repeatedly found that paper and pencil tests are inadequate tools to validly measure children's knowledge.

In cognitive anthropological studies, the researcher attempts to understand the world view of the culture through analysis of the language of members of that society. When the researcher is a native speaker of the language being studied, the researcher must be aware of his or her

underlying assumption that the informants and the researcher share meanings for the words they use. In order to get at the meanings of the informants' words, the ethnographer must start off with an assumption that meanings are not shared.

An ethnographic approach can produce a large amount of baseline data about a culture or topic. Data obtained from multiple interviews are closer to the empirical knowledge of the individual than data obtained from a single test. The use of a variety of questioning strategies allows the researcher to ask some of the same questions in a variety of ways. The various techniques allow triangulation of data, which increases the likelihood that the data are reliable and valid.

The study was conducted in two stages. The first was a series of interviews with nine sixth grade students. The second stage involved analysis of the elementary textbook series, *Silver Burdett Science*, 1985.

Stage One: Interviews with Students

Prior to beginning the study, I conducted a pilot study with five students, ranging in ages five to ten. The informants were asked to describe and name the plants viewed in an outdoor setting. I used the pilot study to test some of the interview techniques to be used in the dissertation research. Results of the pilot study have not been discussed here.

For the dissertation research, nine sixth grade students from a medium-sized university town in central Texas participated in a series of interviews. The interviews included two loosely structured sessions in outdoor settings and four more highly structured sessions indoors.

The Interviews

(* = indicates what procedures were developed during the progress of the study.)

1. Slide sets: each informant was asked to identify the plants viewed in a series of slides.

2. Listing tasks: each informant wrote a list from memory of the names of plants belonging to the major categories that were identified in the slide task (e.g., *trees, bushes*).

3. Neighborhood walk: the researcher accompanied each informant on a walk, beginning in the informant's own yard and proceeding through the neighborhood. Using open-ended questions, the researcher asked the informant to describe and name the plants and parts of plants viewed in the outdoor setting. The sessions were tape-recorded.

* 4. Sorting tasks: Each informant freely sorted a series of photographs of plants into categories, and described the characteristics of the categories.

* 5. Concept mapping exercise: each informant developed a series of concept maps about plants,

while the researcher asked questions about the needs of plants, the parts of plants, the functions of plants, and human uses of plants.

6. River walk: the researcher accompanied each informant along a trail unfamiliar to the child. One trail was used for all informants. Further descriptive questions were asked about plants viewed in the outdoor setting. * In addition, questions were asked about the needs of plants, the functions of plants and plant parts, the differences between living and non-living things, the differences between plants and animals, and human uses for and dependence on plants.

Data Analysis of the Interviews

In order to address the various questions of interest, a variety of data analyses were required. The researcher completed the following:

1. Discourse analysis: The researcher read through the interview transcripts several times in search of patterns, relationships, and inconsistencies. In particular, names for plant parts and the child's explanations of abstract botanical phenomena were extracted (e.g., the functions of flowers and leaves, the differences between plants and animals).

2. Domain analysis of strict inclusion: Lists were made of the names for the major plant categories used by each informant (e.g., *tree, bush*) and the plant specimens included in each category.

3. Domain analysis of attribution: Lists were made of student's statements about the attributes used to identify the major plant categories (*tree, bush,* etc.).

4. Categories for Plants: componential analysis, based on the domain analyses, was used to evaluate students' meanings for each category, including the type of criteria used for category selection, the boundaries of the category, and the salience of the category.

5. Taxonomic analysis: The componential analysis was used to examine the student's model of the hierarchical relationships between plant categories.

6. Names for Plants: Using the componential and taxonomic analyses, the researcher formed inferences concerning what levels of abstraction in naming plants were linguistically and psychologically basic for the informants.

7. Types of errors: using the domain analysis of strict inclusion, the following were examined: (a) informants' abilities to recognize the same species in different settings, (* b) types of errors made in naming plants, (c) tendencies to overdiscriminate plant species, and (d) tendencies to overgeneralize plant names.

8. Listing tasks were reviewed to determine how many and what types of names for plants students remember.

9. The outdoor sessions and concept maps were reviewed for students' explanations for concrete and abstract botanical phenomena (e.g., names for parts of plants, reproduction, the importance of plants to humans).

Stage Two: Textbook Review

The science textbook series used in public elementary schools in central Texas was *Silver Burdett Science,* 1985. The researcher reviewed textbooks from grades one through six. In addition, a brief review was made of the seventh grade text, *Life Science*, Macmillan Publishing Company, 1986.

Textbook Review

1. Lists were made of the botany related propositions included in grades one through six.

2. A list was made of the major botanical topics covered in the seventh grade text.

Data Analysis

1. Discourse analysis: All botanical propositions were reviewed in search of patterns, relationships, and inconsistencies. As a result the following lists were compiled and the following aspects of the text were evaluated.

* 2. Lists were made of the names for plants and major plant categories found in the elementary textbooks.

* 3. Lists were made of the botanical terms used in the elementary textbooks.

* 4. Concept maps were drawn of the botany related propositions in grades one through six.

* 5. Using the above lists and the concept maps, the language of the text was analyzed. The researcher classified botanical terms as either folk or scientific terms. Names for plants found in the text were classified as being familiar or unfamiliar to children in central Texas.

6. Concept development in the elementary text was examined. Comparisons were made with the students' interpretations of the concepts.

* 7. The pedagogical emphasis of the text was evaluated.

<p style="text-align: center;">Definitions of Terms</p>

Abstract: thought of apart from any physical objects. An abstract concept refers to a concept that cannot be perceived by the senses.

Category: A set.

Classify: to categorize, group, or sort (Lowery, 1981, p. 75).

Concept: "A perceived regularity in events or objects designated by an arbitrary label" (Novak, Gowin, & Johansen, 1983, p. 625). For example, *tree* is a label for a concept possibly defined as a large plant characterized by one or more woody trunks.

Concrete: Designating an object or class of objects that can be perceived by the senses.

Domain: The set included within a category.

Ethnobotany: the study of the folk botanical knowledge of a culture.

Level of abstraction: Refers to the hierarchical levels in a biological classification system. "The greater the inclusiveness of a category..., the higher the level of abstraction" (Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976, p. 383).

Berlin, Breedlove, and Raven (1973) designated the following labels for the *levels of abstraction* in a folk biological taxonomy: *unique beginner* is the most inclusive category at the top of the hierarchy (e.g., plant, animal); *life form* is the next level of abstraction (e.g., tree, bush, grass are types of plants); *generic* refers to the next level (e.g., oak, pine, maple are types of trees); *specific* refers to the next level (e.g., Spanish oak, bur oak, live oak are types of oaks); the lowest level of abstraction is the *varietal* (e.g., plateau live oak is a type of live oak).

Misconception: "an incorrect interpretation" (The American Heritage Dictionary). A misconception in science may be thought of as an interpretation of a natural phenomenon which differs from the scientifically accepted view.

Monothetic concept: A concept "defined in terms of one or a small set of criterial features" (i.e., necessary and sufficient conditions for category membership, Hunn, 1982, p. 836).

Polythetic concept: A concept "distinguished by many features" (Hunn, 1982, p. 836).

Proposition: "Two or more concepts semantically 'linked' to illustrate a specific regularity" (Novak et al., 1983, p. 626). If *bud* and *flower* are both concepts, then "bud becomes flower" is a proposition. The researcher considers that a proposition is itself a type of concept.

Taxonomy: "A system by which categories are related to [one] another by means of class

inclusion" (Rosch, et al., 1976, p. 383).

Summary

This was a two-part study. Ethnographic interviews were employed to examine the botanical language, meanings, classifications, and interpretations of concepts of nine sixth grade students. To provide a basis for comparison, the elementary science textbooks used by the students were analyzed also.

A review of the literature related to this report has been included in Chapter II. The research design has been detailed in Chapter III. Much of the raw data has been placed in the appendices.

Interpretations of the data have been presented in Chapter IV. Chapter IV has been divided into four sections: Categories for Plants, Children's Plant Classification Schemes, Names for Plants, and Textbook Concepts Compared with the Conceptions of the Child. Following Ken Tobin's suggestion (personal communication, April, 1990), the interpretations of the data have been labeled *assertions*. Level 1 assertions are the inferences made directly from the raw data. Level 2 assertions are one step away from the raw data. Level 3 assertions are two steps away from the raw data. Recommendations for research are level 3 assertions.

Chapter V has included a summary of the assertions and a discussion of the limitations of the study. The chapter ends with a discussion of the implications of the study for educators and cognitive anthropologists and others interested in theories of meaning and cognition or the study of cultural linguistic development. Suggestions have been made for further research.

CHAPTER II - REVIEW OF RELATED LITERATURE

The literature review has been divided into four sections. In section 1, "Children's Science Versus Scientists' Science," research has been reviewed on student misconceptions in science. Some theories of concept meaning have been reviewed in section 2, "Language and Meanings." In section 3, "Names for Plants," a model for evaluating folk biological hierarchies has been examined, and research has been presented on the basic level of abstraction for naming plants. Finally, section 4 presents a review of research on science textbooks.

Section 1: Children's Science Versus Scientists' Science

The Child's Conceptual Framework

Considerable research has been conducted on children's misconceptions in science (see Fisher & Lipson, 1986; Helm & Novak, 1983; Osborne & Freyberg, 1985). For example, misconceptions have been documented concerning student conceptions of life (Brumby, 1982; Tamir, Gal-Choppin, & Nussinovitz, 1981), and heat and temperature (Erickson, 1979). In his dissertation research, Trembath (1980) explored the origins of misconceptions.

A misconception may be defined as any interpretation of natural phenomena that differs from the scientifically accepted view. From the point of view of the scientist (or the science teacher), the child's explanations of natural phenomena are often viewed as misconceptions.

In the past many revolutionary theories introduced by scientists have been perceived at first as misconceptions. These theories were not the result of a lack of knowledge, rather they were the result of creative thinking built upon a large data base. When presenting a new theory, the scientist must persuade the scientific community that his or her theory better explains the phenomenon in question. If the scientist succeeds, the alternative theory becomes part of the accepted body of scientific knowledge.

Children differ from scientists in the size and content of their data base, in their experience with the scientific process, and in their persuasive abilities. In addition there are developmental differences (see Carey, 1985, for a new model of conceptual development). Nonetheless many children have creative theories to explain the world around them (Piaget, 1929). Many explanations of children, even when erroneous, have been thoughtful, reasonable responses (Confrey, 1983; Driver, 1983).

Several dangers lie in approaching the study of children's interpretations of scientific concepts from the point of view of misconceptions. By focusing on misconceptions, the research has tended to overemphasize what the child does not know and neglected to examine what the child does know. There also has been a tendency to judge any explanation that differs with the scientifically accepted view as wrong without examining the reasoning behind the response.

Paper and pencil tests, such as the National Assessments, have frequently been used for

evaluating misconceptions. These types of tests have verified that students do have misconceptions about specific topics and provide demographic information on what populations have more misconceptions. However, these tests provide no information on the reasoning behind students' responses. The researcher must be careful not to overlook the possibility that some "wrong" answers are based on true scientific inquiry, and some "right" answers are based on an incomplete understanding of a concept (Goodyear & Renner, 1975).

The addition of interviews to paper and pencil tests in some studies has increased the amount of useful information that can be gleaned from research on misconceptions. For example, in a study on student conceptions of living and nonliving, Tamir et al. (1981) asked questions that provided the students' rationale for selecting various objects as living and nonliving. Dreyfus and Jungwirth (1988) also used interviews to examine the reasonings behind student responses to a questionnaire on the cell concept.

When responding to a question, the child often is presenting a reasonable interpretation based on what the child already knows. Hills (1983) stated that, "perception is influenced by the concepts, beliefs, expectations, and prior knowledge of the observer. Hence, confronted with the same phenomena ... adherents of different theories will observe different things" (p. 266). From the point of view of the child's experience and theoretical framework, there may be several logical interpretations for a single phenomenon.

Interpretation or hypothesis formation is a creative act involving more than just the summation of facts. Even when presented with the same data that a scientist has, the child may interpret data differently (Driver, 1981; Osborne & Wittrock, 1983).

Osborne and Wittrock (1983, p. 496) have proposed that the child and the scientist go about the process of constructing meaning "from their experiences and long-term memory" in roughly the same manner. Novak (1983, p. 119) stated his belief that "all normal children have essentially the same cognitive operational capacity as adults." Individuals differ not in their capacity but in the "disciplinary specific concepts and propositions" they possess. Carey (1985, p. 199) points out that "knowledge is restructured in the course of acquisition."

Some researchers consider the child's explanations of scientific phenomena naive or idiosyncratic (Fisher & Lipson, 1986). Although the child's explanations may in some ways be idiosyncratic, the language and meanings of the child are learned from experiences with the culture in which he or she is immersed. From birth the child is continuously receiving instruction from parents, peers, and by direct experience with the environment. By the time the child arrives in school, he or she has developed quite a large data bank of knowledge about the cultural and physical setting. To say that the students' interpretations are naive may be erroneous or at least an oversimplification.

The Commonsense Framework

While the child's explanation of natural phenomena appears naive from the scientific viewpoint, the researcher must not overlook the possibility that the child's explanation may be consistent

from the viewpoint of the adult layperson. Hills (1983) has suggested that the child's interpretation differs from that of the scientist because the child is working within a different theoretical framework, what Hills calls the "commonsense framework" (p. 268).

To explain the difference between the commonsense framework and the scientific framework, Hills used the concept *fruit* as an example (p. 269). In the commonsense framework, fruit is a sweet, fleshy food. To the botanist a fruit is "the ripened ovary or ovaries of a seed-bearing plant... containing the seeds" (*The American Heritage Dictionary*, 1979). Using the botanist's definition, a fruit does not have to be sweet, fleshy, or edible. In this case, the commonsense meaning differs from the scientific meaning. Both meanings of *fruit* have validity within their own linguistic contexts.

What Hills called "commonsense" meanings, the anthropologist would call "folk" meanings. Kempton (1981, p. 3) explained that, "Folk systems are used by the common people, have multiple authors... are transmitted informally from generation to generation, and change through time." Folk terms, rather than scientific terms, comprise the majority of terms used in a language.

Although scientific language and meanings ultimately have their beginnings in folk language, the vocabulary of today's scientists often differs markedly from that of the layman. Even when using the same vocabulary, the scientist may define words (e.g., *fruit*) in a different manner.

For the child, folk language and meanings have relevance on a daily basis. The language and meanings of the scientist may have relevance only for the few minutes each week that the child engages in the study of science in the classroom. If the language and meanings of the scientist differ from those of the adult layperson, it should not be surprising that the child (who learns from the adult layperson) has so many apparent misconceptions in the context of the science class.

Hills (1983, p. 271) suggested that differences between the scientist's and the child's interpretations may reflect a "gap or tension between theories." If the child's explanations are viable in the framework of adult folk culture, that may explain why many misconceptions are widespread and tenacious. Even when the child's explanations differ from those of the adult layperson, the child's idiosyncratic explanation will probably be based on the language and meanings of adult laymen.

It would be surprising to find large discrepancies between the child's language and meanings and those of the adult. Communication breaks down if the language and meanings of the child are not comparable (or at least overlapping) with the language and meanings of his or her culture. Nonetheless, some idiosyncratic differences in language and meaning can be expected.

To determine the extent to which the child's interpretations are based on a body of knowledge acceptable to the adult layperson, the researcher can examine the child's language and meanings. Does the child use the same language as the adult layperson and/or the scientist? Does the child apply comparable meanings to concepts as does the adult layperson and/or the scientist? Are the child's idiosyncratic interpretations of scientific phenomena based on the language and meanings

of the folk culture rather than the language and meanings of the scientific culture?

If Hills' interpretation is accurate, then the science teacher who is ignorant of the importance of the commonsense (folk) language and meanings will unknowingly be speaking in a foreign language when introducing the scientific language and meanings. If the science teacher does not recognize the existence and validity of the commonsense framework when presenting scientific concepts, she or he will have difficulty convincing the child of the validity of the scientific framework.

The researcher must examine the possibility that the child's interpretations of scientific phenomena may be valid from the point of view of the adult folk culture. There is also the possibility that some of the child's meanings for words differ somewhat from that of the adult layperson as well as from that of the scientist. If language and meanings differ markedly, communication will break down in the science classroom. Thus the science educator may have to take into account differences between the scientific framework, the commonsense (folk) framework, and the idiosyncratic (child's) framework in order to communicate effectively the pertinent body of scientific knowledge.

Researchers should be wary of the assumption that the child and the scientist work from the same conceptual framework. If the researcher sees the child as moving from naive to expert, then the researcher may assume the child and the scientist are on a conceptual continuum. The failure of our education system to produce a scientifically literate populace suggests that the child and scientist work from different conceptual frameworks. The fact that some children do grow up to become scientists implies that the frameworks of child and scientist must overlap enough to allow the child to make the transition from the commonsense framework to the scientific framework.

Children's Science and the History of Science

In a number of recent studies, researchers have made comparisons between the interpretations of natural phenomena given by early scientists and those given by children. For example, some similarities have been found between the child's view of the earth and the cosmos and early theories of cosmic origins (see Nussbaum, 1979; Osborne & Gilbert, 1980; Piaget, 1929). Out of these comparisons has emerged the theory that the development of scientific thinking in the child recapitulates the history of scientific thinking. This theory appears to be based on the assumption that the conceptual framework of the child and the scientist are on a continuum. Lythcott (1983) examined numerous research articles in which children's interpretations were said to be similar to Aristotelian explanations of natural phenomena. After analyzing the studies, Lythcott concluded that it was erroneous to say that the children believed the same things that Aristotle believed.

Similarities between the child's interpretations and those of early scientists might merely reflect the closer links between the conceptual framework of the early scientist and that of the layman. The scientist is, after all, also a product of his or her culture.

Abstract Versus Concrete Science Concepts

I had one final concern about current trends in research on misconceptions. In reviewing the literature, it appeared that almost all research on children's misconceptions in science has dealt with abstract concepts (see Gilbert, Osborne, & Fensham, 1982; Helm & Novak, 1983). In the field of botany, most studies have dealt mainly with the concept of photosynthesis (Barker, 1986; Barker & Carr, 1989a & b; Simpson & Marek, 1987; Smith & Anderson, 1984; Smith & Lott, 1983; Wandersee, 1986) or photosynthesis and respiration (Murr, 1986; Treagust, 1988).

Even studies conducted with elementary students have emphasized abstract concepts. For example, Lawson (1988) examined a variety of concepts related to plants and animals, including photosynthesis and reproduction. Research has demonstrated that children of all ages have misconceptions related to abstract science concepts.

This author wonders why few researchers have examined children's meanings for concrete scientific phenomena. By focusing on abstract concepts, researchers belabor the obvious, that children, particularly in the elementary years, have trouble with concepts that are not related to concrete examples. No one seems to be looking at children's knowledge of the concepts that form the basis for the abstract concepts.

If new ideas must be linked to prior knowledge, why is no one trying to find out more about the prior knowledge that is necessary to the understanding of abstract scientific phenomena? Before you ask a child to explain the function of a leaf (photosynthesis), you had better find out what the child means by the term *leaf*. Before you ask the child to explain plant reproduction, you had better find out what he or she knows about flowers.

A few studies have examined children's meanings for concrete botanical concepts. Osborne and Freyberg (1985, p.7) report on a study in New Zealand by Beverley Bell. She found that some students do not think that trees or seeds are plants. Some thought that plants differ from weeds and that carrots are vegetables, not plants.

In Israel, Lazarowitz (1981) developed a classification ability test for seventh and ninth grade students. One of the 13 sections involved naming and classification of plants. He found that the students generally performed poorly on the test. There was a high positive correlation between scores on the classification test and various intelligence tests.

Askham (1972) compared the attributes children use to classify plants in a natural setting with the attributes used to classify geometric objects indoors. Askham found that the children used a greater variety of attributes when describing plants. Askham has suggested that related research should also be conducted in a natural setting. However, Askham did not directly test the natural setting against the classroom setting. If he had intended to do that, he should have compared children's descriptions of plants in a natural setting with descriptions of plants (not geometric objects) in an unnatural setting (such as in photographs or herbarium specimens). This researcher suspects that differences between the indoor and outdoor setting were much less significant than

differences between the types of objects studied. Askham's informants probably provided a greater variety of attributes when looking at plants simply because plants have a greater variety of distinguishable attributes than do geometric objects.

In the field of cognitive anthropology, Dougherty (1972) and Stross (1973) examined children's names for plants. These two studies have relevance to other aspects of this study and are reviewed in a later section of this chapter.

Summary

In summary, several trends in the research on misconceptions have led the author to conclude that this type of research has limited application. These studies have tended to examine children's meanings for abstract concepts and neglect examination of the concrete concepts that form the basis of understanding abstractions. Focus on misconceptions has led to an emphasis on what the child does not know to the neglect of what the child does know. Paper and pencil studies without the inclusion of interviews have provided limited new information or insights into this new research area.

Researchers must be aware that the following assumptions may be misleading: explanations that differ from the scientifically accepted view have no value; the child and the scientist use the same conceptual framework, therefore, the student's knowledge proceeds on a continuum from naive to expert; the child's interpretations are naive and idiosyncratic and therefore unrelated to any body of knowledge accepted within the culture.

Lythcott (1983) concluded that it is erroneous to state that children's explanations for natural phenomena recapitulate Aristotelian explanations. Hills (1983) suggested that the child views the world from the commonsense framework. Although differing from the scientific framework, the commonsense framework is based on the folk culture and has validity from the point of view of that culture.

Rather than examining the conceptions of the child from the point of view of the scientist, with an eye to what is right and what is wrong, the researcher may need to take the point of view of the anthropologist who examines first what is. In this study the language, meanings, and classifications of each of nine children have been examined. A comparison was made with the language and meanings of the other individuals, the adult layperson, and the scientist. Children's interpretations of both abstract and concrete concepts were examined. It was hoped that the study would provide information on the rationale behind student explanations of scientific phenomena. It was also hoped that the study would demonstrate the extent to which the idiosyncratic framework of the child differs from or resembles the commonsense framework and the scientific framework.

Section 2: Language and Meanings

As this study was designed to evaluate the child's language and meanings, I reviewed some theories on the meaning of a concept and the meaning of meaning.

Novak et al. (1983) have defined a concept as, "a perceived regularity in events or objects designated by an arbitrary label" (p. 625). They have stated the belief that "concepts do not have 'fixed' meanings.... Concept meanings are developed primarily in the extent that they are embedded in frameworks of propositions, and hence it is the set of propositions that a person has incorporating a given concept that defines that person's idiosyncratic meaning for the concept" (p. 626). In other words, meaning depends on context and the meaning that one individual gives to a concept may very well be different from that of another.

Concepts may have concrete referents (e.g., *car, dog*) or they may represent abstract ideas (e.g., *God, love*). Regardless of whether the referent is concrete or abstract, a concept itself is a generalization and therefore an abstraction. In this study, the term category was used in reference to the set that represents a concept (e.g., *trees, bushes).* Spradley (1979, p. 98) pointed out that by placing elements in a category we treat them as though they were equivalent.

Novak et al. (1983) have used the term proposition to refer to "two or more concepts semantically 'linked' to illustrate a specific regularity" (p. 626). If *seed* and *flower* are both concepts, then "seeds form within flowers" is a proposition. This researcher considers a proposition itself as a type of concept because it portrays a single idea.

Theories of Meaning

In a study of the folk classification of ceramics, Kempton (1981) claimed that he was examining referential meaning. Macnamara (1982) stated his belief that "meaning is distinct from reference....reference has to do with designating what one is talking about, and meaning has to do with describing it" (p. 210). I disagree with Macnamara's assertion that meaning is not abstracted from the sensory array. I believe that Kempton has indeed examined meaning (Kempton's research has been detailed below). Various aspects of Macnamara's theory of meaning, however, shed light on what will be examined in the current research.

Macnamara distinguished between the meanings that people have for concepts and the features used to recognize examples of the concepts. He also distinguished between meaning and the concept itself. He pointed out that the layman may not know what determines whether something is water (e.g., the chemical composition) and yet know how to recognize examples of water. The layman has a meaning for the concept without knowing the necessary and sufficient conditions that define the concept.

Meaning "is the manner in which the concept is presented" (p. 216). Macnamara stated that meaning denotes "something that ordinary people have in their heads.... meaning must be attainable without a scientific training, and meaning must be the same for all who use a word to

communicate" (p. 211).

This researcher contends that meaning is not absolute. Novak et al. (1983) stated that a single concept can have multiple idiosyncratic meanings. Kempton's theory, described below, has provided one explanation of how people can have idiosyncratic differences in meaning and still be able to communicate.

Macnamara pointed out that meanings of concepts can be differentiated either intrinsically (such as differentiating water from gold by chemical composition) or extrinsically (such as differentiating the phenomena of cat and dog by the fact that one purrs and the other barks). Meanings are differentiated on the basis of differences among observable phenomena.

Although stating that reference is not the same thing as meaning, Macnamara conceded that the ability to correctly categorize objects is a good indicator that the individual has grasped the meaning of a concept/category. It is possible, however, for someone to recognize examples of a concept without grasping its meaning. Macnamara gave the hypothetical example of a child who knows the term chopsticks, knows how to recognize examples of chopsticks, but does not know their function.

This researcher suggests that ability to place objects into hierarchical relationships with other objects is an additional indicator of whether or not the child has grasped meaning. If, for example, the child is able to place chopsticks with other types of eating utensils in a sorting task, the child has indicated that he understands the function of chopsticks. Coupled with accurate classification of chopsticks, this would provide substantial evidence that the child grasps the meaning of the concept *chopsticks* as perceived by an adult.

Macnamara (1982, p. 211) said that a concept is defined by the "necessary and sufficient conditions for category membership." For concepts such as dog and tree, however, there are no necessary and sufficient conditions. Macnamara explained this problem by stating that those conditions exist but are as yet unknown to us. Despite his protestations to the contrary, Macnamara appears to cling to the positivist stance that a concept has an absolute essence.

In contradiction to Macnamara's stance, we have already seen that the layman's meanings for words can differ markedly from those of a scientist. The scientist and the layman can discuss fruit, refer to the same objects as fruit, and yet still have different intrinsic meanings for fruit, meanings which depend on a different set of criterial attributes.

In the current research, the child's meanings for concepts such as *tree* and *bush* have been examined. Macnamara would say that this study has not really defined the child's meaning for *tree*. But at a certain point, Macnamara's argument becomes circular and meaning becomes meaningless.

Whether or not the current research actually defines meaning may be irrelevant as long as the researcher can demonstrate how well the child's meanings compare with those of adults. For

example, if a child and a scientist call the same objects *trees*, that may be regarded as an indicator that the child and the adult have comparable meanings for the concept *trees*. If the child uses *tree* in the same hierarchical manner as would an adult, that provides further evidence that the child grasps the meaning of *trees*. If the child is able to list various uses for trees, that adds further evidence of comparable meanings.

Categories and Meanings

> "When symbols function as categories, they serve to reduce the complexity of human experience.... Without symbolic categories for everything we experience, we could become hopelessly enslaved to the particular. One of the most important functions of every human language is to provide people with ready-made categories for creating order out of the complexity of experience" (Spradley, 1979, p. 98).

Folk systems are "classification systems because they divide the world into named segments" (Kempton, 1981, p. 3). Devised classification systems, such as the taxonomic systems used by botanists, are created by and follow conventions decided upon by a group of scientists. Folk classification systems are not consciously created by a group of people and do not follow a mutually decided upon set of rules (p. 4). It was the folk classification systems of sixth grade children that were examined in this study.

Rosch and Mervis (1975, p. 573) pointed out that in the past linguists and psychologists had assumed that linguistic categories have distinct boundaries and membership that is defined by a set of criteria possessed by all members. By this model a category (concept) is defined by a set of necessary and sufficient conditions that distinguish it from all other groups, which is the positivist view.

Kempton (1981) stated his belief that this model of the meaning of a category ignored the importance of too many features. A tree cannot be defined simply by the presence of wood and a single tall trunk, as stated in dictionary definitions. Kempton said that, "Sneath and Sokol emphasize that systematic biology advanced tremendously when it was realized that a category 'does not necessarily possess any single specified feature.' They observe that this realization meant the end of the Aristotelian concept of an essence of a category" (p. 16).

Prototype Theory

Research by Rosch and Mervis (1975) and Kempton (1981) has supported an alternative model of meaning based on the concept of a prototype. The prototype is the "clearest case, best example of the category" (Rosch & Mervis, 1975, p. 574). Category membership is determined by the degree of resemblance to a prototype. Rather than having distinct boundaries, the attributes of natural categories overlap, that is, some of the attributes of one category are shared by other categories. Of all members of the category, the prototypical members bear the largest number of attributes relevant to the category and have the least resemblance to members of contrasting categories.

Kempton (1981) pointed out that:

> "Perhaps the most important difference between folk classification and devised classification is the use of grading. The elements of most folk categories are graded from prototypical examples in the center to atypical ones on the fuzzy boundary of the category.... Although grading is now becoming accepted as an aspect of folk classification, it is antithetical to the purpose of many devised classification systems.... Since devised classification systems had traditionally been considered exemplary of all classification, grading had traditionally been ignored in studies of folk classification" (p.4)

Kempton (1981) examined prototypes in his study of names for types of ceramic containers in Mexico. He had the informants name and define the attributes they used to distinguish between various pottery mugs and jars. The informants described the number of handles or the presence of spouts (attachments) and the function (e.g., for cooking). They did not verbally define the shape, though they defined it by pointing or drawing. He noticed that the verbal folk definitions and dictionary definitions for the pottery terms he was studying "both oversimplify by omitting crucial information, especially the important component of vessel shape" (p. 36). Kempton found that the definitions did not provide enough information to allow someone unfamiliar with the language to use the term correctly. Verbal folk definitions and dictionary definitions both assumed a shared cultural background between the speaker and the listener.

To overcome this difficulty, Kempton had the informants explain their classifications. By pointing out apparent discrepancies in category selection and having the informant justify the selection, Kempton was able to discover the importance of the height-to-width ratio (shape) in category selection.

Next, Kempton developed a series of drawings of the objects. The sheets of drawings enabled him to depict the objects with variations of the features (number of handles, height-to-width ratio, length of neck). Each informant examined the sheets of drawings, naming the objects on the sheets and circling all the objects that fit the informant's idea of *jarro, olla*, et cetera. Then, Kempton asked the informant to designate which drawings were the best examples of an *olla* (for example), and of those drawings that were not *ollas*, which were sort of *ollas* (p. 49). Thus, four grades of membership were discovered, simple membership (all objects that are examples of X), focal membership (the best examples of X), peripheral membership (sort of X), and nonmembership (everything else).

Using this technique, Kempton was able to examine category membership of pottery vessels as viewed by different types of informants. He found differences between older and younger informants, men and women, potters and nonpotters, and differences between informants from traditional and more modern villages.

Kempton found that the groups differed widely in their simple members but tended to have the same prototypes (focal members). Thus differences between groups appeared in the rules of extension. For example, the experts - potters and women - allowed more variation in shape and

less in attachments than did nonexperts. Number and type of attachments was related to the function of the object. He also found that the features important to category membership (neck position, width-to-height ratio, and attachments) tended not to differ between groups. Features simply varied in how they were weighted between groups. In other words, variation could occur in the features, thus category membership could change, but the same features were used to select the members.

Kempton found that "categories are structured as a prototype symmetrically surrounded on all sides by successively lower grades of membership" (p. 167). He noted that features were additive. "The features of shape and attachments interact with each other, each adding to category membership" (p. 57). The presence of either feature by itself was enough to allow some specimens to be included in the category. Both features together defined the focal members.

Rather than making category selections feature by feature, category membership was based on "distances from a prototype" (p. 99). "Membership is similarity to prototype. This clean conceptualization of membership places features and dimensions in the background" (p. 103). Kempton formulated a radial model of category membership, with the prototype in the center of the circle, and other members included within the circle at varying distances from the center.

Although the prototype was central to category membership, individual features, the components of meaning, affected meaning - if a feature deviated too much from the prototype, the object no longer belonged in the circle. Kempton pointed out, in addition, that not all important features were graded. Some features, such as presence or absence of a spout, were discrete. Nonetheless, the total number of features present in a series of specimens was graded, whether or not individual features were graded or discrete.

In attempting to define a category, if one described the prototype only (as sometimes occurs with dictionary definitions), the definition would be too restrictive as it would exclude everything that did not share all features of the prototype. If one described only the features important to category membership, the definition would again be too restrictive, as such a definition would ignore the additive and interactive aspect of the features.

Kempton suggested that in defining category membership, one should "describe the prototype... [and then give] the culture's rules for judging similarity to the prototype" (p. 103). "A prototype-based definition includes additional features possessed by the prototype but not by other members of the category. It therefore defines the entire category as the prototype and things similar to it" (p. 197). Thus category membership is defined by the prototype with extension.

Despite Macnamara's objections (1982), I had no trouble with Kempton's assertion that he was examining meanings. Even considering Macnamara, Kempton has clearly demonstrated which informants have a shared meaning for *jarro*. Although Macnamara (1982) has not agreed that the prototype represents the meaning of the concept, he has seen the value of prototypes to categorization.

Macnamara (1982) said that in order for communication to be possible, meanings must be the same. Kempton (1981) found that his informants were able to communicate meaningfully with each other about *jarros* even though they selected different referents. The objects designated as *jarros* varied considerably between informants but the objects designated as prototypes varied less. As long as their prototypes were similar the informants shared enough components of meaning to be able to carry on meaningful conversation about *jarros*. Thus prototype theory provides an explanation of how communication is possible despite idiosyncratic differences in meaning.

Macnamara (1982) pointed out some limitations of prototype theory. While prototypes have worked well for explaining the selection of members of categories at low levels of the taxonomic hierarchy (such as *fish* or *dogs*), they have not worked well for the broader, more abstract categories (such as *animals* and *plants*). Macnamara pointed out that *animal* is a superordinate term, referring to a collection of lower level categories. "'Animal' is differentiated from 'plant' by the set of subordinate categories" (p. 220) rather than by a prototype based on attributes. This insightful explanation needs further examination in regards to prototype theory but it does not detract from the value of the prototype in expressing meaning.

Summary

In summary, concepts are not absolute. Individuals may have idiosyncratic meanings for concepts. Prototype based definitions of meaning appear more applicable to concepts such as *dog, jarro*, and *tree* than a concept of meaning based on necessary and sufficient conditions such as Macnamara (1982) has proposed. Kempton (1981) found evidence in support of the theory that categories are based on a prototype with extension. He found that although individuals may have idiosyncratic differences in what objects they place in a category, their prototypes are similar. Thus communication is possible even when individuals have idiosyncratic referents.

In the current research, the informants' plant categories have been examined to see whether children rely on prototypes or necessary and sufficient conditions for selecting members.

Section 3: Names for Plants

In anthropology a relatively new field has developed called "cognitive anthropology." Cognitive anthropology is the study of the interrelationship of human cognition with language and culture. It involves an attempt to describe "how cultural knowledge is organized in the heads of people" (C.H. Brown, 1984, p. 3). In essence, it is the study of the conceptual framework of culture through analysis of language and its meanings. Some of the earliest work in this area was conducted by anthropologists engaged in the examination of folk biological taxonomies (ethnobiology).

Cognitive anthropologists examine two aspects of cultural knowledge, "What material phenomena are significant for the people of some culture; and how do they organize these phenomena?" (Tyler, 1969, p. 3). Although early cognitive anthropology has tended to emphasize differences

between cultural groups, a comparative study by Berlin, Breedlove, and Raven (1973) revealed common trends in the naming and classification of plants and animals in various language groups. Out of these trends, Berlin et al. developed a set of general principles of nomenclature and classification. As the principles developed by Berlin et al. provide the model for the taxonomic analysis in this study, that model is outlined here.

A Taxonomic Model

In their studies Berlin et al. (1973, 1974) found that folk categories for plants fall into a limited number of hierarchical levels, five or six taxonomic ranks. Figure 1, below (photocopied from the original dissertation book), shows the hierarchical relationship between the taxonomic categories.

The levels were labeled as follows:

unique beginner - the most inclusive category (e.g., *plant, animal*);
life form - the taxonomic level immediately below unique beginner (e.g., *tree, grass, vine*);
generic - the level usually immediately below life form (e.g., *oak, maple, willow*);
specific - the level immediately below and included in the generic (e.g., *Spanish oak, bur oak, live oak*);
varietal - the level immediately below and included in the specific (e.g., *plateau live oak, coastal live oak*).
An intermediate level, usually unlabeled, sometimes occurs between the life form and generic ranks (e.g., *evergreen*).

Berlin et al. (1973) found that in some cultures the unique beginner level was not labeled, that is, some cultures did not have an all-encompassing name for plants and animals. Because of the tendency not to encode these categories, Berlin et al. labeled the unique beginner level 0. Boundaries between the categories that English speakers call *plants* and *animals* seem to be implicit. Berlin et al. found that even when not labeling the unique beginners, informants did make clear distinctions between plants and animals.

Berlin et al. found that while life form names always occur at the next level, level 1, some generic names may also occur there. Specific names are always included within a generic class and occur at either levels 2 or 3. Varietal names are always included within a specific class, and occur at either levels 3 or 4.

Some generic names (e.g., *bamboo*) are not included within any life form category. These "unaffiliated" generics are "almost without exception cultivated and/or morphologically peculiar in some fashion" (p. 219). Berlin (1976) stated that "ambiguously affiliated generics" (generics included under more than one life form) are also morphologically peculiar (p. 387). Some are polymorphic with classification varying with form.

Berlin (1972, p. 54) found that the lower level folk biological taxa (particularly generics) generally correspond rather closely to scientific biological taxa (*genera*). The close correspondence was not

surprising as scientific taxa are also based on perceived morphological similarities.
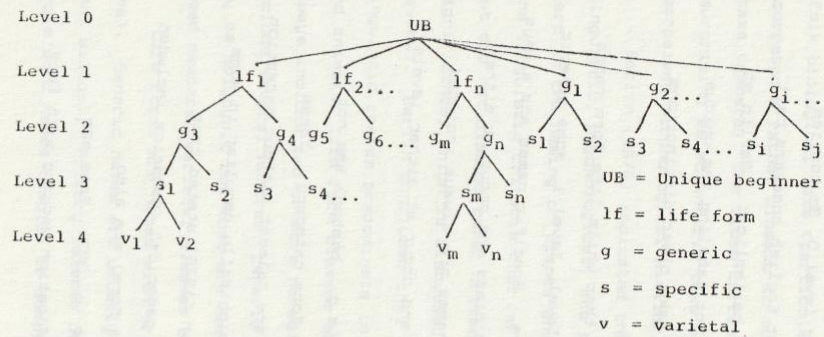
Figure 1. Schematic relationship of the five universal ethnobiological taxonomic categories and their relative hierarchic levels in an idealized folk taxonomy. Note. From "General Principles of Classification and Nomenclature in Folk Biology" by B. Berlin, D. Breedlove, and P. Raven, 1973, The American Anthropologist, 75:1, p. 215. Copyright 1973 by the American Anthropological Association. Reprinted by permission.

Figure 1. Schematic relationship of the five universal ethnobiological taxonomic categories

Berlin (1976) indicated that various criteria, linguistic, psychological, and biological, all play a part in the naming of plants and animals. He defined the linguistic criteria that he considered significant but did not discuss other criteria (except cultural significance, which is discussed later in this review). Berlin concluded that the following linguistic trends predominate in the naming of plants and animals: life form classes are polytypic - they always include two or more named members and some include several hundred; generic and specific classes may be polytypic but most are terminal, containing no named members; varietal classes are terminal.

Life forms are named with primary lexemes (*tree, vine*). Generic names are usually primary lexemes (*oak, willow*). Primary lexemes can be either simple, single word names (*maple*) or complex, compound names. If complex, either the compound name does not include the name of the superordinate class (*devil's claw, Dutchman's breeches*) or, if it does include the name of the superordinate class (*oak tree*), that name is in direct contrast with some other generics named with simple primary lexemes (*maple, ash, willow*).

Specific and varietal names are usually secondary lexemes (a compound name composed of the generic label plus a modifier, e.g., *live oak* - specific; *plateau live oak* - varietal). The members of a specific or varietal class will all have the same base name (*bur oak, white oak, red oak*), with some exceptions explained by Berlin (1976).

Berlin (1976) found these linguistic trends to be generally reliable and has been able to satisfactorily explain most exceptions. The model is a subject for debate (see Hunn, 1982) and further research is needed.

Encoding of Life Forms

In an overview of ethnobotanical studies of 188 languages, C.H. Brown (1984) compared trends found in different languages. His study provided much data in support of Berlin's model. Like Berlin he found that several life form classes appear over and over again in languages.

Brown described the attributes of the major plant categories found in the most number of languages. He signified those categories by the following terms: tree (large woody plants), grerb (small nonwoody plants), bush (bushy plants of intermediate height), vine (plants with elongated stems that creep, twine, or climb), and grass (non-flowering herbs with narrow leaves). Brown found the English terms useful for signifying all but one category, grerb. English speakers in the United States do have a category for small nonwoody plants, but the label they use for that category is *plants*. To avoid confusion Brown chose to use the invented term, grerb, to signify that category. Grerb is a combination of the English terms grass and herb.

In addition to being encoded more often than other categories, these categories "typically include more labeled categories than other general purpose plant classes" (C.H. Brown, 1984, p. 13-14). These five categories appear to be the most salient life forms for people in a wide range of cultures.

C. H. Brown found that life forms appear to be added to languages in "relatively invariant orders" (p. 23). He found that of the 32 possible combinations of the five most salient life forms, only 14 combinations are actually used in 188 languages. Brown asserted that <u>tree</u> is virtually always the first life form encoded in a language (a few languages may lack <u>tree</u>). Either <u>grerb</u> or <u>grass</u> is typically encoded second, with more languages encoding <u>grerb</u>. The other two categories are typically encoded third, with <u>vine</u> encoded more often than <u>bush</u>. Figure 2 (below) presents Brown's developmental model of the order in which botanical life forms are encoded in languages.

Stage. 1   2   3   4-6
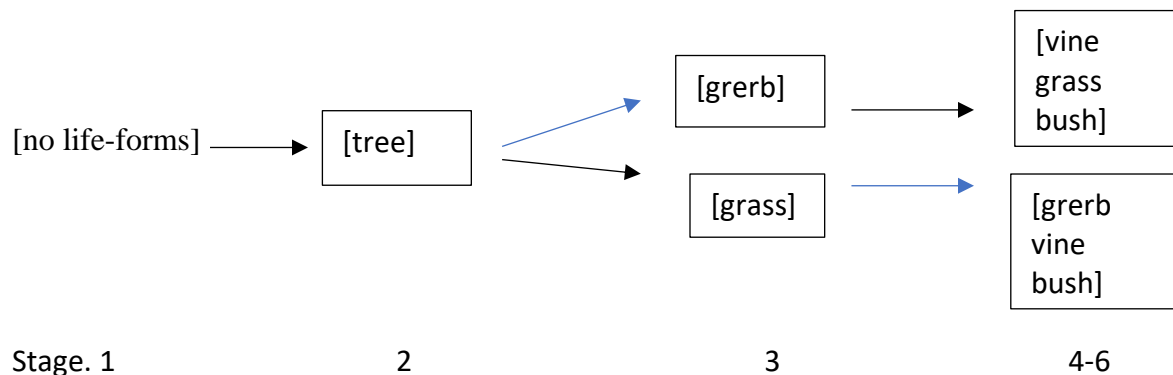
Figure 2. Botanical life-form encoding sequence

<u>Note</u>. From *Language and living things: Uniformities in folk classification and naming*, by C.H. Brown, 1984, New Brunswick, NJ: Rutgers University Press. Copyright 1984 by Rutgers, The State University. Reprinted by permission of Rutgers University Press.

Using Berlin's linguistic trends as the sole guideline, C.H. Brown found that not all major plant categories qualify as life forms. For example, <u>grass</u> is a major class in many languages, occurring at level 1 in the taxonomic hierarchy, but it's members often are named with secondary lexemes. Linguistically, <u>grass</u> appears to be a generic name. Psychologically, however, it seems to serve as a life form.

C.H. Brown (1984, p. 269) labeled as life forms "all general plant and animal classes which reflect certain pan-environmental, large biological discontinuities in nature." I used a similar convention in this study.

Some categories that C.H. Brown analyzed serve as life forms even though they had no named members. Linguistically they would qualify as generics. Brown called them <u>incipient</u> life forms. He found that incipient categories are used to label unknown, unnamed specimens. For example, Chase (C.H. Brown, 1984, p. 80) found that American children under age five may recognize ducks by name without knowing that they are types of birds. The young child tends to use *bird* only in reference to birds the child cannot name. In this case *duck* is not included in *bird*.

Bird, then, starts out as an incipient category. As the child ages he or she will eventually include *ducks* within the category *birds*, and *birds* will become a full life form category, fitting into an

inclusive taxonomic scheme. Brown documented cases in which adults in several cultures used incipient life forms (C.H. Brown, 1984; Brown and Chase, 1981). He suggested that the incipient life form is an embryonic category, a transitional stage, that will become a full-fledged life form later in the linguistic development of the culture (or in the case of Chase's young child, later in the linguistic development of the individual).

Hunn (1982) called categories with unnamed members residuals. The residual category does not fit into Berlin's hierarchical model because set inclusion is lacking. Hunn cited the example of the John Day Sahaptins of northwestern North America. Informants from this culture have a label to cover unnamed grasses that is not used in reference to named grasses. A residual category represents empty taxonomic space and serves linguistically as a "means to dismiss all organisms not deemed worth recognition on their own account" (p. 834).

Hunn has contended that a residual category may never develop into a true life form. Brown and Chase (1981) suggested that full life forms develop out of residual categories. They theorized that as the members of a society become less dependent on their environment, they add more and more unnamed specimens to the residual categories. Eventually, even the named specimens are included in the residual category, and it is then considered a true life form.

Macnamara (1982) suggested that the child's linguistic usage more closely mimics that of the adult than has been assumed. He noted a tendency in adults in Canada to use *bird* for naming unknown specimens (p. 49). It would appear that the adult tends to use the label *bird* as a residual category. In this case, the adult allegedly would be aware that *bird* also includes named members, but the child would not. Thus the child's usage would be incipient, and the adult usage would be residual. Macnamara's observations provide an indication that the residual nature of a life form category does not necessarily disappear when named members are added to the category. The nature of residual categories will be explored further in this study.

Basic Level of Abstraction

Berlin et al. (1974) and Rosch and Mervis (1975) have stated that there is a "basic level of abstraction at which the concrete objects of the world are most naturally divided into categories" (Rosch & Mervis, 1975, p. 586).

Berlin et al. (1974) asserted that languages have few life form names for plants, typically less than ten, and that generic names make up the vast majority of all names for plants. Specific names are fewer than generic names and varietal names are rare. Berlin et al. concluded that the generic level constitutes the most psychologically basic or salient level of abstraction in naming plants. "Generic taxa are consistently labeled in folk biological taxonomies" (Berlin, 1976, p. 387). On the other hand, some languages lack unique beginner, life form, or varietal ranks. Berlin (1982) speculated that in the development of a language, generic names appear before the first life form or specific names.

The salience of the generic level of naming has been demonstrated in numerous studies (e.g., C.H.

Brown, 1984). Stross (1973) concluded that the generic level is the most salient level for naming plants for Tzeltal children as well as adults. At age two, children already had generic names for various plant products (e.g., *banana, corn*). Thus Stross provided evidence that generic names are among the first names children learn. Although suprageneric names (*grass*, *tree, vine, herb*) are also used by the very young child, specific and varietal names are added later, perhaps beginning around age four.

Basic Level in Urban Versus Rural Societies

While the generic level of naming seems to be the most salient in virtually all cultures studied, most studies have been conducted with small-scale societies with low technological development (Berlin et al., 1973; C.H. Brown, 1984). In small-scale societies, it is not unusual for individuals to know the generic names for several hundred plants (C.H. Brown, 1984). Although few ethnobotanical studies have been conducted in urban societies, the evidence indicates that individuals in these urban cultures are able to name far fewer plants at the generic and specific levels.

Berlin (1972) speculated that in complex technological cultures, as individuals lose knowledge of names for plants, specific and varietal names disappear first. As generic names are lost, individuals must rely more on life form names.

C.H. Brown (1984) documented the frequency of written words in American English and found that *tree, grass, bush*, and *vine* were among the most frequently used plant terms. He asserted that in American English life forms have increased in salience. Brown found a relationship between societal scale and number of biological life forms. Small-scale societies tend to have fewer life forms than large-scale urban societies (p. 51-3).

Further research is needed in other large-scale urban cultures to determine how widespread is the trend towards increased use of life form names. While it seems reasonable that life forms have increased in use, and thus are becoming linguistically salient, there is currently not enough data to document what has happened to the psychological salience of the generic classes in those cultures. Rosch, Mervis, Gray, Johnson, and Boyes-Braem (1976) and Dougherty (1972. 1979) have claimed to document the decreased salience of generic classes in the United States. The author, however, has questions about the conclusions drawn from both studies, as has been explained below.

Biological Versus Nonbiological Categories

Using a variety of approaches, Rosch et al. (1976) have studied the basic level of abstraction in urban American culture. They found that for some objects, notably man-made objects such as furniture, clothing, and vehicles, the generic level (*chair, shirt, car*) was the level most salient for the subjects. They concluded, however, that in the biological realm a level superordinate to the generic level was basic (e.g., *trees*).

The series of studies by Rosch et al. were well designed and each experiment added triangulating evidence in support of the others. A couple of factors, however, may need to be reexamined. First, there are some major differences in the classification of man-made versus biological objects. Attributes used to define plants and animals tend to rely on form, whereas attributes used to define man-made objects tend to rely on function (as is also true for the category *fruit*). Thus some differences in results between the two groups (biological and nonbiological taxonomies) may be confounded by the differences in types of attributes used for classification.

In addition, the man-made objects used in the study do not fit into the same taxonomic scheme as do natural objects. *Trees, fish,* and *birds* can be included under a unique beginner (plants, animals]). But what is the unique beginner for <u>musical instruments</u> and <u>tools</u>? Such a level of abstraction does not seem to exist linguistically or cognitively in our culture. This researcher wonders how this difference affected the results. Dougherty (1978) also pointed out some problems with these studies but did not call into question the conclusions.

The conclusions drawn from Rosch et al. (1976) in experiment 1 are called into question. Based on a comparison of the number of attributes subjects listed for nonbiological and biological taxonomies, Rosch et al. concluded that the basic level for biological taxonomies is superordinate to the level predicted by Berlin. The nonbiological categories were *musical instrument, fruit, tool, clothing, furniture, vehicle*. The biological categories were *tree, fish, bird*.

I question two aspects of the study. First, there appears to be more diversity within each of the superordinate categories of man-made objects than within the biological category. This is demonstrated by the particular examples chosen. A drum and a guitar have fewer attributes in common than an oak and a maple, thus the list of common attributes for musical instrument will be shorter than for tree.

Rosch et al. have ignored the natural diversity in trees by selecting only broadleaf deciduous trees and omitting palms and conifers. The examples may represent the prototype trees for the investigators and their informants, but they do not represent the natural diversity in trees growing in California. The examples of fish in the study also seems limited to the investigators' prototype fish. The examples of birds were more diverse, but not as diverse as if Rosch et al. had included, say, penguins and ostriches (though admittedly, there are not very many of these in California, and many people would not recognize them as birds).

In summary, the validity of comparing biological with nonbiological categories has been called into question. The differences in results between biological and nonbiological groups may have been an artifact of (1) the different types of attributes commonly used to describe biological and nonbiological entities (form versus function), (2) the taxonomic incompatibility of the two groups, (3) a difference in diversity between the biological and nonbiological categories, and (4) a bias towards the prototype in terms of the particular biological examples chosen. These studies need to be re-evaluated taking these factors into account.

Children's Names for Plants

Dougherty (1972, 1979) has contended that for children in California, the life form level has become more salient than the generic for naming plants and animals. Stross' study in Mexico (1973) and Dougherty's studies in the United States have provided the beginnings of a body of data for comparison of children in large- and small-scale societies. More studies with children are needed.

Stross conducted a developmental study in Mayan Mexico (Tzeltal) with 25 children (beginning at age two) and 10 adults. By age four, the Tzeltal child could name more than 100 plants, many with generic names. By age 12, the average child could correctly name as many plants as a below-average adult in that culture, using many generic and specific names and some varietals. Adults and children used a total of 209 plant names.

Dougherty studied six children ages 3-8, one child at each age level (1972, 1979), and six children ages 2-3 (1979) in urban California. Her children knew few generic names for plants (the eight year old child named about 20), few specific, and no varietal names. Dougherty concluded that the life form level is salient for children in the United States. She also has asserted that life forms are learned before generic names.

The majority of names used by Dougherty's youngest informants were life forms. Evidence within the study, however, shows that generic names also were used at the earliest ages. The first plant names learned by the youngest children (1979) were generic names for plant products (e.g., *banana*). In the cross-age study (1972), the three year old child used a few generic names for wild plants (e.g., "apple tree," " root tree"). This child also used the made-up names, "pine needle tree" and "leaf tree." Dougherty considered these names to be intermediates but this author wonders if they could have been overgeneralized generics. In either case, I contend that these made-up names represent attempts to name specimens at a less abstract level than the life form.

Dougherty has developed a model of the stages at which taxonomic ranks are encoded by children. She has placed life forms at the first stage and generics at the second stage. She interpreted "pine needle tree" as an intermediate level name yet she did not place intermediates with life forms at the first stage of her model in the 1979 article, although she did so in an earlier article (Dougherty, 1978).

From her cross-age data, Dougherty (1979) developed a model of linguistic development in which children at first have a restricted use of a category (e.g., for the young child, only the cedars in the child's yard are recognized as "cedars"), followed by overgeneralization (the child starts to call various similar looking trees "cedar"), and ending in appropriate redefinition of the category. As she has admitted, the small number of informants (one child at each age from 3-8) did not provide Dougherty with enough data to be certain that the differences between the children were not idiosyncratic rather than developmental. As will be seen, the results from the current research indicate that several relevant differences between children in Dougherty's sample may have been idiosyncratic.

Kendler and Guenther (1980) stated that no research has demonstrated clearly a developmental relationship for classificatory behavior. Their research demonstrated that both overdiscrimination and overgeneralization occur at very early ages. For their subjects at ages 3-4, overgeneralization occurred more frequently than overdiscrimination but its frequency rapidly diminished with age. Overdiscrimination occurred with relatively low frequency at the early ages, increasing at first (in their study, the increase occurred between ages 3 and 6) and then decreasing. Correct classifications improved gradually with age. In their study overdiscrimination was much more common than overgeneralization between ages five and eight. Anglin (1977) found overdiscrimination to be more common than overgeneralization among preschool children (ages 2-5).

<u>Summary</u>

In summary, the generic level of naming appears to be linguistically and psychologically salient for naming plants and animals in small-scale societies with low technological development. There is limited evidence that in large-scale urban societies the life form has become linguistically salient for naming plants and animals. Not enough data has been generated to demonstrate what happens to the psychological salience of generic names in large-scale societies. More studies are needed in large-scale societies to clarify the questions raised in this review.

<center>Cultural Significance of Names</center>

<u>Differential Salience Related to Cultural Use</u>

Dougherty (1978) and Rosch et al. (1976) have concluded that the linguistic salience of taxonomic levels varies from individual to individual depending on the types of objects referred to. The life form may be the basic level category for one group of objects while the generic is basic for others. For an ornithologist, the specific level may be basic in reference to birds, but the life form level may be basic in reference to butterflies. Salience seems to vary depending on use, familiarity, and individual interest. Other factors probably come into play as well.

Cultural significance may be the single-most important factor in determining whether or not the generic or life form level is linguistically salient for plants. In cultures that still depend on wild plants for food, shelter, and medicine, a much greater knowledge of generic and specific plant names seems to exist than in the modern technological cultures of today.

Stross (1973) provided direct evidence of the importance of culturally useful plants in the learning of plant names. The first generic names learned by the very young child were names of plant products. As the child ages, he or she knew more names for plants, often supplying information on the plant's uses. By age 12, the child could name the plant, describe its use, the method of preparing the plant for use, and the habitat. The older the child, the more likely that he or she could also name plants that were not culturally important. Culturally significant plant names, thus, were learned first and were the most salient in the botanical vocabulary of the Tzeltal culture.

Macnamara (1982, pp. 48-9) found that at age 2 1/2, children in French-speaking Canada were able to name various fruits at the generic level. Dougherty (1972) also found names for food products were the first plant names children remember. All these yield additional evidence that cultural significance affects the salience of generic plant names.

Berlin (1976) found an interesting relationship between nomenclature and cultural significance. In Aguaruna, 81 percent of generic taxa that are divided into specific and varietal classes have cultural significance. Thus cultural significance increases the likelihood that a plant will be named at the specific or varietal level.

If cultural significance is related to the level of abstraction used for naming of plants, then it is not surprising that the diminishing cultural significance of wild plants in large-scale urban societies has resulted in the loss of knowledge of generic and specific names for plants. As members of the culture become less dependent on wild plants for food, medicine, and shelter, they have little or no practical need to learn names for those plants. They do still need to know the names of the agriculturally important plants in their environment in order to select foods to eat and woods with which to build houses.

Reference Versus Context in Naming Plants

Hunn (1982) also noted that cultural significance plays an important role in the naming of plants. He found that residual categories were often composed of specimens that lacked cultural significance, indicating that culturally unimportant plants were most likely to remain unclassified at the generic level. Hunn criticized Berlin's model because Berlin assumed morphological characteristics to be of primary significance in naming plants. Hunn felt that Berlin failed to fully take into account the importance of cultural significance in plant nomenclature and classification.

In support of Hunn's argument, M.F. Brown (1985) demonstrated that morphological characteristics had minor significance in the naming of magical stones in Aguaruna society. His informants relied heavily on personal experiences (e.g., dreams) as criteria for selecting names for these special stones. He concluded that cultural significance was more important than morphological attributes in the naming of magical stones.

The rules for naming magical stones do not have to be the same as rules for naming useful plants, however. First of all, the morphological attributes of stones (form, size, color) are not related to their magical powers (unless the individual picked up a piece of uranium). On the other hand, plant morphology can be directly related to use (e.g., vines for weaving, wood for lumber, fleshy fruit and soft green leaves for food). Secondly, because magical stones get their power from a supernatural rather than a physical source essentially any stone will do the job. The same is not true for a plant used for medicine or food. The user risks injury or death if he or she does not rely on morphological attributes to identify the correct medicinal or edible plant.

In a study of Ilongot in the Philippines, Rosaldo (1986) found that plants used in magical spells for

healing were named in an inconsistent fashion. The same name could apply to unrelated plants, and some plants had as many as 13 different names. These magical herbs were not ingested. Rosaldo concluded that "while names are attributed partially on the basis of morphological discriminations, their use and meaning is not determined by a referential scheme" (p. 480). How the plants are used, and what they signify in terms of an individual's wealth or power, determine how they will be named. Although names for magical herbs are highly variable, Rosaldo found that names for poisonous and edible plants were much more stable, more closely tied to morphological distinctions.

Morphology did play a role in naming the magical herbs, however. Rosaldo noted a correspondence between one Ilongot category of magical herbs and the botanical category, the orchid family. All of the named orchid species were used for magical spells. Names for the healing orchids were not used for other types of plants. Within the whole group of magical orchids, names could vary. One name could refer to any of the members of the whole set of orchids used to signify one particular type of healing spirit. "Orchid names may be understood, then, not as pointers, indices of discrete segments of experience - discrete plant types - but as the signifiers of a general concept which gives contextual significance to a chosen set of plants" (p. 478).

Berlin's model seems to depend on a one-to-one correspondence of reference (one name refers to one botanical entity). Rosaldo found that names often do not correspond so neatly to reference. Berlin (1976) did address cultural significance in some detail in discussion of his study of Aguaruna plant names. In that language two-thirds of all generic taxa had cultural significance. Nonetheless, a large number of the plants named at the generic level lacked cultural significance. Linguistic evidence demonstrates that morphological criteria do play a role in naming plants (names for plants are often descriptive). Nonetheless, there is mounting evidence that morphology is secondary to use in deciding which plants will be named.

Summary

In summary, Berlin et al. (1973) have developed a model that seems useful in examining the hierarchical relationships between folk categories for plants. They asserted that the generic level of abstraction is basic for naming plants, at least in small-scale rural societies. Some research suggests that the life form level of abstraction has become salient in large-scale urban societies. C.H. Brown (1984) asserted that certain plant categories occur in most languages and are encoded in languages before other categories.

Hunn (1982) found that the model by Berlin et al. does not account for residual categories. Morphology and cultural significance seem to interact in determining plant nomenclature and classification. Berlin's model may need to be re-evaluated to take into account the importance of cultural significance in naming plants.

Section 4: Review of Research on Science Textbooks

The elementary textbook series *Silver Burdett Science*, 1985, was analyzed in this study. A review of textbook analyses relevant to the study has been included here. The topics of interest were the language used in science texts, the concept development in the texts, and the pedagogical emphasis of the texts.

Language of Textbooks

In an analysis of K-12 textbooks, Yager (1983) found more scientific terms introduced in the science texts than foreign language words in foreign language textbooks. In learning a foreign language, the student learns new names for concepts the individual already comprehends. In science, the new terms typically refer to concepts that the student is not already familiar with, concepts that often are abstract. In another examination of terms used in science texts, Daugs and Daugs (1974) found many of the non-scientific terms just as difficult for students as the scientific terms.

In a comparative analysis of four elementary science textbook series, Meyer, Crummey, and Greer (1988) found that the Silver Burdett series consistently had the largest number of vocabulary words averaging "from two to five times the number of vocabulary words per content domain as the Merrill program" (p. 439). Other science textbooks analyzed were Holt and McGraw-Hill. Beyond grades four, all the texts introduced a large number of vocabulary words (typically more than 200 per grade). For Silver Burdett the number of vocabulary words in grades one through five were 241, 277, 243, 288, and 466 respectively. Clearly, the textbooks place an undue emphasis on vocabulary.

In *Project 2061: Science for All Americans,* the American Association for the Advancement of Science (AAAS, 1989) pointed out that much of the scientific terminology found in textbooks is not essential to the learning of science concepts. The association has recommended reducing the amount of vocabulary found in science textbooks.

Concept Development in Elementary Texts

Staver and Bay (1989) analyzed the development of science concepts in eleven texts, kindergarten through grade three. They concluded that concepts were developed differently in different texts. Using concept maps to analyze a unit on air and/or weather in each of the texts, Staver and Bay found that "some texts present many more concepts and relations between concepts than do others" (p. 344). In some texts, the concepts were quite complex. Staver and Bay asserted that the concepts in the texts require concrete operational reasoning. They concluded that the reasoning demands the texts place on the reader are above the developmental capabilities of many primary students. In most of the texts the concepts were well defined but in two texts some isolated concepts appeared on the concept maps. For example, in a unit on weather, wind and clouds are discussed in isolation from other weather concepts.

Pedagogical Emphasis of Texts

Project Synthesis (Harms & Yager, 1981) involved a synthesis of several evaluative studies on children's progress in science. School science programs were evaluated in terms of the desired state and the actual state. Pratt and associates (in Harms & Yager, 1981, pp. 75-76) proposed a desired state wherein elementary science education would focus on the following major goal clusters: the personal needs of the child (including skills for application of science in daily life), societal issues in science, academic preparation in science, and careers in science. They found that no single elementary science text or program was designed to adequately cover all four goal areas. The goals could be met through combinations of various program materials, however.

Staver and Bay (1987) conducted a study of the pedagogical emphasis in eleven elementary science textbook series. The researchers examined the texts in relationship to the recommendations of Project Synthesis. Staver and Bay found that the texts focused on the academic goal cluster. Some texts covered some topics related to the personal needs goal cluster. Little or no information was provided on careers in science or the relationship of science to society. In addition, little space in the text was allocated to activities and experiments. Few experiments used even a limited inquiry approach. Staver and Bay concluded that elementary texts "clearly devote most of the space to [academic] concept development" rather than skills (p. 641).

In a survey of five physical science textbooks, Chiappetta, Sethna, and Fillman (1987) found that four placed their greatest emphasis on science as a body of knowledge rather than as a way of thinking. There was some emphasis in the texts on investigative activities.

In a position statement the National Science Teachers Association (NSTA, 1982a) recommended goals for the percentage of instructional time to be devoted to process skills, concept development, human applications, and science-based societal issues in each grade. The NSTA has recommended devoting about 66 percent of kindergarten science instruction to the development of process skills. By sixth grade, time spent on skills can drop to about 37 percent. From kindergarten to sixth grade, concept development should only take up 25 to 40 percent of instructional time. About 10 to 25 percent of science instruction should be devoted to human applications of science. And societal issues, although possibly not appropriate in kindergarten, should take up about 15 percent of science instruction by sixth grade (Staver & Bay, 1987).

The AAAS (1989) has developed goals for scientific literacy for all Americans. Science curriculum should address the scientific world view, scientific methods of inquiry, and the nature of the scientific enterprise. Recommendations have been included for the scientific concepts appropriate for the science curriculum, concepts such as evolution, food chains, and ecosystems. The guidelines are aimed at providing all students with the "knowledge, skills, and habits of mind associated with science, mathematics, and technology that all Americans should have by the time they leave school" (p. 19).

Summary

Reviews of science textbooks have revealed too great an emphasis on scientific vocabulary. Staver and Bay (1989) asserted that elementary science textbooks place reasoning demands on the reader that are above the developmental capabilities of many primary students.

The research seems to demonstrate that today's science textbooks emphasize science as a body of knowledge rather than as a way of thinking (Chiappetta, Sethna, and Fillman, 1987). Academic concepts have been emphasized to the neglect of the development of science process skills (Staver & Bay, 1987). The large amount of vocabulary to be learned, the preponderance of abstract concepts, inconsistent and highly complex concept development, an undo emphasis on academic concepts, and too little emphasis on careers in science, human applications of science, and societal issues in science: all these trends in science texts conflict with the recommendations of science education researchers, the NSTA, and the AAAS.

CHAPTER III - METHODOLOGY AND PROCEDURES

Introduction

This was a two part study. Using ethnographic interviews, I first examined the botanical concepts and classification schemes of nine sixth grade students in central Texas. Secondly, an analysis was made of the botanical concepts in the elementary textbook series *Silver Burdett Science*, and the seventh grade text, *Macmillan Life Science*.

The meanings for botanical concepts as presented by the text were then compared with those of the children. Both were evaluated in relationship to the meanings for those concepts held by botanists. Such a comparison enabled me to (1) discover both the strengths and weaknesses in the students' botanical knowledge; (2) determine the extent to which the students' knowledge reflects what they had read in the elementary text; (3) evaluate the extent to which the science textbooks reflected the recommendations for science education made by the NSTA and the AAAS; and (4) evaluate the extent to which the textbook bridged the gap between the knowledge base and abilities of the child and the knowledge base of the botanist.

The study progressed as follows:

- Pilot study - spring, 1986

- Interviews - winter-spring, 1988

- Textbook review - spring-summer, 1989

Research Design

Qualitative ethnographic techniques were used for data collection and analysis. The informants participated in several interviews. Outdoor interviews allowed me to make first hand observations of children as they manipulated, described, and discussed plants in natural settings.

The environment in which the plant grows, bark characteristics, and size of the plant all provide cues to plant recognition that are often missing in a photograph or drawing. To ascertain which characteristics are important to the child in classifying a plant, the best setting in which to work is, therefore, the natural setting.

The indoor interviews provided alternate methods for examining questions asked in the outdoor setting. Each interview provided a different way of looking at some of the questions explored in other interviews. Miles and Huberman (1984) call this technique triangulation and explain that it involves using a series of imperfect measures to validate findings. The measures are imperfect in that some are invented after the research has begun, and validity and reliability of the individual measures have not been determined. Each measure (or interview), however, provides

triangulating evidence to support or challenge the findings of other measures. The validity and reliability of the measures as a whole depends on the extent to which the responses to one interview technique match the responses to other techniques.

In this research, slides, listing and sorting tasks, and outdoor interviews all were used to examine students' names and categories for plants. Hierarchical relationships between categories were explored in outdoor interviews and listing and sorting tasks. Comparison of responses to plants seen in the slides and in the outdoors provide evidence concerning what levels of the taxonomic hierarchy were most salient for students. Students interpretations of abstract concepts, such as the function of flowers and leaves and human dependence on plants, were explored using concept maps and outdoor interviews. Student's names for plant parts are explored using concept maps and outdoor interviews.

Some of the early interviews provided data for development of later interviews. Data from the slide task and the first outdoor interviews provided direction for development of the sorting task and concept mapping exercise. Data from the first outdoor interview and concept mapping exercise provided questions for the second outdoor interview. The questions of interest for the textbook review emerged from findings of the early stages of analysis of the interviews.

Stage One: Interviews with Students

The Participants

Due to the time consuming nature of data collection and analysis in ethnographic research, these studies typically include a small number of informants, each of which is interviewed in depth.

I chose informants from the three ethnic groups prevalent in the area. Informants included one African-American male, two Mexican-American males, one Anglo-American male, and five Anglo-American females. A total of nine informants were used. I had hoped to use students from both rural and non-rural backgrounds. All the informants, however, had grown up in town, so no truly rural informants were included. The students came from a variety of economic backgrounds and had a wide range of achievement test scores (see Table 1 below).

Diversity is useful in ethnographic inquiry. By using informants from different backgrounds I was able to find out what trends were likely to occur regardless of differences in ethnicity, gender, or school performance.

I chose students from sixth grade, as representative of the knowledge accumulated throughout the elementary school years. Thus the data obtained from the study will be useful for the development of science curricula for the elementary grades and for seventh grade life science.

The informants were volunteers from a medium-sized university town in central Texas. Due to the time-consuming nature of the interviews, volunteers were a necessity. The informants were paid

for their time. The interviews were conducted after school.

Table 1 displays a profile summary of each informant. The table lists the ethnic background of each child and indicates whether the child lives in a rural or non-rural setting. Play preference, indoor or outdoor, was determined by asking the children (on paper) to choose the places they liked to play the most, in the house, outside, in the yard, or in the woods or fields near home. The children who chose only "in my house" received the designation "indoor play."

Table 1: Informant Profiles

Informant Identification Number									
Profile	1	2	3	4	5	6	7	8	9
Male/Female	F	F	M	M	F	F	M	F	M
Ethnicity[a]	AN	AN	MA	AN	AN	AN	AF	AN	MA
Rural/Nonrural	R	N	N	N	N	N	N	N	N
Indoor/Outdoor	I	I	O	I	O	O	O	I	I
MAT Scores[b]									
Complete Battery	99	93	29	97	98	99	50	87	71
Science NP[c]	99	67	50	99	99	99	83	72	59
Science Stanine	9	6	5	9	9	9	7	6	5

[a]Ethnicity: AN=Anglo-American; AF=African-American; MA=Mexican American
[b]MAT= Metropolitan Achievement Test 6
[c]National Percentile

If the child chose any of the outdoor options (even if they also chose the indoor option), they received the designation "outdoor play." The test scores are from the Metropolitan Achievement Test 6, taken in the sixth grade. NP means "National Percentile."

All informants had attended public schools in central Texas all their lives. Thus, the informants theoretically had the same formal educational exposure. They all had grown up in the same biogeographic region. Thus, all plants viewed in the field were plants that the students could have seen before, and all students had been exposed to the same science textbooks.

Because the students came from a relatively small city, with under 30,000 people, students had had some of the same teachers. Several of the informants were in the same science class at the time of the study. Thus it was possible that some responses the students had in common may have been influenced by one or two teachers.

Procedures for the Interviews

I interviewed the informants individually, with the exception of the slide sets which occasionally

were presented to two informants at once. Spradley's interview techniques were followed for the open-ended interviews (Spradley, 1979).

The interviews included two loosely structured sessions in outdoor settings and four more highly structured sessions indoors. As an overview of the procedures has been included in Chapter I, the following section has stated the objectives of each interview and a detailed description of each type of task.

Session 1: Slide Sets I and II

Objectives of the slide sets:

1. Examine the informant's names for plants.

2. Discover the informant's categories (such as tree, bush) for a wider range of plants than might be encountered in the field.

3. Examine the informant's use of life-form, generic or specific names for plants.

4. Evaluate the effectiveness of using slides for teaching botany in the classroom.

Slide set I: Of the 34 species in slide set I, the researcher chose 17 that she predicted would be difficult for the students to identify at the generic level. The species are common in central Texas. The slides were either of the whole tree, shrub, or other specimen from a distance, or of a plant or plantlike object (ferns, lichens, mushrooms) known to be difficult for lay adults to name at the generic level. Enough information was contained in these slides for a botanist to properly identify the species. I predicted, however, that the child would be uncertain of their identity and would name these slides at a more abstract level than the slides in set II.

Slide set II: The slides in this set included close-up shots of common plants, beginning with a rose. Full shots of trees, herbs, et cetera, were included with close-ups. Some species were the same as in slide set I. The researcher predicted that the slides in this set would be easier for the informant to recognize and that the informant would use more generic or specific labels than in slide set I.

Refer to Appendices A-1 and A-2 for a list of the species shown.

Procedures for the slide sets:

Time - one hour

The researcher showed each informant slides of a wide variety of plants commonly found in central Texas. A total of 64 species of plants were included in the two sets.

The researcher stated: "There are no wrong answers. I just want to find out your names for these

plants."

The researcher showed each slide and asked: "What is it?" or "What do you call it?" or "What is its name?" The informant wrote her or his response on paper.

<u>Session 2: Listing Tasks</u>

Objectives of the listing tasks:

1. Discover which plant categories had included members.

2. Obtain information on the hierarchical relationship of the informant's plant categories.

3. Examine the types of plant names the child remembers (economic plants, wild plants, et cetera).

Procedures for the listing tasks:

Time - 30 minutes

Using the responses from the slide sets, the researcher developed a hypothetical list of the plant categories used by each informant. For example, based on responses to the slides, the researcher inferred that for informant 3 the labels <u>tree, mushroom, cactus, weed, fern, vine, bush, fungus, grass,</u> and <u>flower</u> represented major plant categories.

To determine which of these terms acted as categories, the researcher needed to find out which included diverse members. Using Spradley's model (Spradley, 1979) the researcher asked structural questions: "In the slide show, you recognized a number of different (trees). Please, make a list of all the different types of (trees) you can think of."

The informant wrote the list. The researcher looked over the list and asked: "Are there any other types of trees?"

If the informant said, "Yes," the researcher wrote the additional names offered by the informant. The researcher continued to ask, "Do you know the names of any other types of trees?" until the informant said, "No."

The listing task was repeated using two or three more of the informant's hypothetical categories, those the informant had used most often in the slide task. After completing a few lists, if the informant had introduced the category plant in the slide show, the researcher asked the informant to list all the different categories of plants.

There was no time limit on writing the lists. In most cases, the informant quit writing in less than 5 minutes.

As the remainder of the categories were expected to have few named members, the researcher wrote the responses as the informant answered the questions:

"Are there any other types of (cactus)?"

"Do you know the names of any other types of (cactus)?"

An example of the verbatim transcripts of the dialogs from the listing tasks has been placed in Appendix C-2.

<u>Session 3: Neighborhood Walk</u>

Objectives of the neighborhood walk:

1. Discover the informant's names for plants and the categories to which they belong.

2. Examine the informant's use of life-form, generic and specific names for plants.

3. Examine the informant's boundaries and meanings for plant categories.

4. Discover the criteria the informant used to classify plants.

5. Discover the informant's labels for parts of plants.

6. Explore the value of using the outdoor setting in botanical study with children.

Procedures for the neighborhood walk:

Time - one hour

The field interviews were informal. The questions were open-ended and not arranged in any set order. The field interviews were tape recorded and verbatim transcripts produced for later analysis (refer to Appendix C-3 for an example of one transcript).

Getting to know and trust the researcher is an important first step in an ethnographic approach. The first field interview, therefore, was conducted in the informant's own neighborhood. In the pilot study, I found that the familiar setting assists in alleviating apprehensions the child may have had about the study. The children relaxed quickly in the familiar setting. They exhibited confidence in their knowledge of their own neighborhood. In addition, the children were aware of the possible hazards in the area (thorny plants and barking dogs) and so possibly felt safer than they might if placed in an unfamiliar outdoor setting with an unfamiliar adult.

In the neighborhood session, the informant and the researcher walked around the neighborhood

looking at plants. Using interview techniques described by Spradley (1979), the researcher started the interview with descriptive questions. Descriptive questions served to elicit names for plants and the characteristics the informant used for classifying plants. These questions ranged from very broad ("Describe what you see around us," or "What are the names of the things you see around us?") to specific ("Describe this thing," or "What do you call this?").

The researcher avoided using any botanical terms (including the label plant) that the informant had not yet introduced, either in the slide sets or in the listing tasks.

After establishing some names for things, the researcher interjected a few structural questions. Structural questions served to uncover information on how the informant had organized her or his knowledge. The questions provided information about the boundaries (meanings) of the plant categories. The researcher used these questions to discover what plants the informant included as members of which plant categories.

Examples of structural questions:

- Are there different kinds of (grass)?

- As we walk along, point out all of the things that are (trees).

- Is this a (bush)?

- What kind of a thing is a (tree)?

The researcher also asked a few descriptive and structural questions about the parts of a plant. For example:

- What are the names of the parts of the (tree)?

- What are the parts of the (leaf, flower)?

At some point during the interview, the researcher introduced a few contrast questions. Contrast questions provide data on meanings of terms (Spradley, 1979). By asking questions about how one thing differs from another, the researcher was able to elicit more details on the boundaries of categories and the characteristics the informant used to place the plant in a specific category.

Examples of contrast questions:

- How can you tell a bush from a tree?

- Are these two trees the same kind of tree?

- How can you tell they are (different, the same)?

Obtaining information on the informants' classification schemes was the primary goal of all sessions up to this point. The researcher viewed the first outdoor session as exploratory, providing an opportunity to find out what other questions were worthy of further study. Thus when an opportunity arose the researcher asked a few questions about other areas of interest, such as the environmental needs of plants and the functions of plant parts. This data provided ideas for some of the questions in the concept map and in the second outdoor session.

Session 4: Sorting Tasks - Contrast Sets

Objectives of the sorting tasks:

1. Examine the informants' categories for a wider range of plants than might be encountered in the field.

2. Obtain information on the boundaries of and gradations within the informant's categories.

3. Examine the criteria the informant used to classify plants.

4. Compare the categories for plants viewed in sorting task with the same species viewed either in the field or in slides.

Procedures for the sorting tasks:

Time - 30 minutes

The informant viewed an assortment of 74 color photographs of a wide variety of types of plants (all photographs were cut out of magazines). See Appendix A-2 for a list of the species.

The informant was asked to sort the photographs into categories or to put the pictures into the groups that go together. With most informants the researcher did not need to suggest which categories to use. Two informants had trouble getting started so the researcher reminded each that one category he or she had used before was trees and suggested that the individual start with that category. No other categories were suggested by the researcher.

After the informant sorted all the photographs into groups, the researcher asked descriptive and contrast questions about the groups:

- "What name would you give this group?"

- "Explain what these have in common that made you decide to put them into the same category."

- "How is this group different from that group?"

To obtain information on the gradation of membership within categories, the researcher asks the following contrast questions for the trees (and occasionally for other groups as well, if time allows):

"Of the trees, which are the most typical (best examples of) trees?"

"Of the trees, which are the least typical (worst examples of) trees?"

"Of the ones that are not trees, which are sort of like trees?"

These contrast questions were based on Kempton's work with the classification of ceramics in Mexico (Kempton, 1981). An example of the verbatim transcripts of the dialogs from the sorting tasks has been placed in Appendix C-4.

Session 5: Concept Mapping Exercise

Objectives of the concept mapping exercise:

1. Examine the hierarchical relationships of the informant's categories.

2. Examine the informant's conceptions of human needs for plants, the environmental needs of plants, and the functions of leaves and flowers.

3. Discover the labels the informant uses for the parts of a plant.

Procedures for the concept mapping exercise:

Time - 30 minutes

Novak and associates (1983) have shown the effectiveness of using concept maps to explore children's conceptual meanings. Novak and Gowin's *Learning How to Learn* (1984) provided the model for the concept mapping task.

The researcher provided the informant with an example of how to do a concept map using the concept "dog." The researcher asked questions such as, "What are some kinds of dogs?," and "What does a dog have?," and "What does a dog do?," as the informant drew the map. Once it became apparent that the informant understood the procedure, the informant was asked to begin mapping plant categories, answering the same questions in regards to plants.

The researcher encouraged each informant to complete two maps of plant categories. The informant chose the categories. Finally the informant drew a concept map based on parts of plants, either leaves or flowers.

When the informant finished each map, he or she explained the parts of the map. If not already

covered by the map, the researcher asked the following questions:

- "What is a (tree) a kind of?"

- "What are the parts of a (tree, leaf, flower)?"

- "What does a (tree) need to survive?"

- "Do (trees, flowers) do anything for people?"

- "How do people use (trees, flowers)?

- "How do trees get (energy, water, food - if those are listed on the map)?"

- "How does (sunlight, water - if those are mentioned) help the tree?

All of the informants' concept maps have been placed in Appendix C-5. An example of the verbatim transcripts of the dialogs have been placed in Appendix C-6.

Session 6: River Walk

Objectives of the river walk:

1. Examine the informant's names for plants in an unfamiliar setting.

2. Explore the informant's abilities to recognize certain plant parts in their diverse forms (particularly leaves, flowers, buds, and fruit).

3. Examine the informant's conceptions of the function of plant parts, life cycles, the difference between living and non-living, plants and animals, the needs of plants, and human uses of plants.

Most of the objectives for the neighborhood walk also applied here, though they were of lesser importance.

Procedures for the river walk:

Time - one hour

The researcher led each informant along the same woodland trail beside a river. The second field site was away from the familiar neighborhood but in the home town. Though the informants were unfamiliar with the site, a number of the plants seen also grew in the neighborhood setting. The second field site allowed the child to examine a greater diversity of plants than could be found at any one site. An example of the verbatim transcripts of the dialogs from the river walk has been placed in Appendix C-7.

A few descriptive and structural questions (such as in the first outdoor session) were used in the second outdoor interview to gain more information on categories. In this session, however, the emphasis was on the child's recognition of parts of plants and concepts related to the function of parts of plants. The researcher asked contrast questions about leaves, flowers, and buds ("How can you tell a seed from a bud; a flower from a leaf; a flower from a bud?"). In asking about the functions of flowers and leaves, the researcher was able to explore the informant's concepts of reproduction and photosynthesis.

In the second half of the interview, the researcher used the outdoor session to further explore the informants' understanding of abstract botanical concepts. These questions could have been asked in an indoor session. As this was the final session the researcher wished to wrap up some loose ends, asking some questions that had not yet been fully covered. In addition the researcher found that in order to make abstract comparisons (living versus non-living, for example) the informants needed concrete examples, thus an outdoor setting was useful for some abstract questions.

The researcher asked contrast and structural questions about living and non-living things, and plants and animals ("What are the different types of living things?" or "How can you tell a tree from a dog; a rock from a flower?"). The researcher also asked questions about the importance of plants to humans ("What are some ways that people use trees?" or "What would happen to us if there weren't any plants?").

Analysis of the Interviews

Unlike most quantitative research, in which data analysis occurs after all data collection is complete, in an ethnographic study, data analysis begins as soon as the first interview is conducted. To explore the various questions of interest in the current research, a variety of data analyses were employed.

1. Discourse analysis: In the early phase of analysis, each interview was scanned as a whole unit. Patterns, relationships, and inconsistencies were noted. Questions for later interviews were derived from this analysis.

The categories for the listing tasks were obtained from a scan of the slide set responses. The sorting tasks and questions for the concept mapping exercise were developed after a scan of the first field interviews. Questions for the final field interview emerged from the first field interview and the concept mapping exercise. I reviewed the field interviews and the concept mapping exercises for informant's concepts of various concrete and abstract questions of interest.

2. Domain analysis of strict inclusion: a domain analysis is an analysis of a single semantic relationship between the domain and its members (Spradley, 1979).

The informants' domains for plants were folk categories such as tree and bush. One semantic relationship of interest was that of strict inclusion. Any statement that can be re-worded to fit into

the phrase, "X is a kind of Y," is an example of strict inclusion. For example, "an oak is a kind of tree," therefore, "oak" is included in the domain (category) <u>trees</u>.

The domain analysis of strict inclusion was used to examine the informant's names for plants and the members of the major plant categories. Using early interviews as sources of data, I developed a hypothetical list of the categories of plants used by each informant. Data from later interviews was used to verify which categories were salient for each informant. Eventually, all interviews and tasks were reviewed and all statements that fit into this semantic relationship were marked. A final list was compiled of the plants included in each category (both plants with and without generic names). The results of the domain analysis for one informant have been placed in Appendix A-3.

To construct a domain analysis the researcher must formulate some preliminary hypotheses from early interviews that are verified by further interviews with the same informant. For example, the hypotheses made from the data from one interview might include the following:

a. Based on responses to the slide sets, it seemed apparent that informant 3 recognize the following folk categories (domains): grass, tree, mushroom, vine, weed, flower, cactus, fern, bush.

b. Each of the included terms listed in the domain analysis is recognized by the informant as a member of the stated domain.

c. Additional included terms have yet to be discovered (these three suggested hypotheses are adapted from Spradley, 1979).

3. Domain analysis of attribution: A similar analysis was conducted on the semantic relationship of attribution. I reviewed the field interviews and other tasks looking for statements that fit the phrase, "X is an attribute of Y." For example, "brown" is an attribute of "trees." "Has branches" is an attribute of "trees."

The domain analysis of attribution was used to evaluate what attributes the informant used to distinguish between major plant categories. See Appendix A-4 for the results of the domain analysis of attribution for one informant.

4. Categories for plants: Componential analysis was used to examine the informant's referential meaning for the major plant categories and the hierarchical relationships between categories. Componential analysis involves a "systematic search for the attributes associated with cultural symbols" (Spradley, 1979, p. 174). In developing a componential analysis, rather than looking at only one semantic relationship, one wants to examine a variety of relationships concerning a particular folk category.

For example, to develop an hypothesis about the criteria used to define the folk category tree, I used the domain analyses of strict inclusion and attribution. A paradigm was developed for trees, using all the members of the trees as the contrast set, and all the attributes of trees as the

dimensions of contrast (for examples of paradigms, see Appendix A-5). In addition to the attributes stated by the informant other attributes were implied by the choices made. I added attributes to the dimensions of contrast that I believed were meaningful for the informant.

The componential analysis enabled me to develop a model of the informant's referents for categories, the informant's attributes for the categories, and the extent of overlap between categories.

5. Taxonomic analysis: The componential analysis was used to develop a hypothetical model of the hierarchical (taxonomic) relationships between the categories. Berlin's taxonomic model (Berlin et al., 1973) was used to develop the students' models.

6. Names for plants: To evaluate the levels of abstraction in the taxonomy that were most salient for the informant, the following analysis was conducted on the responses from the slide sets and from the field interviews:

a. Each response was coded (see Appendix C-1 for an example of the coded responses to the slide sets).

- Names were coded as either G, S, or L. G = generic label; S = specific label; L = any label more abstract than a generic (may include life form, unique beginner, or intermediate levels of abstraction). For example, "oak" is a generic label (G), "tree" is a life-form (L), and "live oak" is a specific label (S). If "evergreen" was used as an intermediate between generic and life form levels it was coded (L).

- X = inaccurate name (must be accompanied with an error code. The error codes were developed as specific tendencies were noted in the early scanning of the interviews.)

- Error codes: EA = common adult layman's error; EN = mistakes a plant for a non-plant; ER = error, related species; ES = error, similar in form; EU = error, cause undetermined; M = made-up name.

- D = description given spontaneously

- N = no response given

In the outdoor interviews segments were omitted from analysis where ever the informant was asked to describe a plant. Passages were included in the analysis only when the informant spontaneously offered descriptive information.

b. For each informant, the following were enumerated: number of cases in which an L, G, or S name was used; number of cases in which a name was accompanied with a description (a "simple life form" is a suprageneric name given without a spontaneous description, a "described life form" is a suprageneric name given with a spontaneous description). The number of suprageneric and

generic responses in slide sets I and II. Number of cases of accurate or inaccurate names. Number of times each type of error was made. The number of non-responses, "I don't know" responses, made-up names, and descriptions without a name.

The number of cases in which any informant used a specific label were so rare that in the final tallies the S and G responses were lumped together. In the field each informant viewed different specimens, thus the results were reported as tendencies, not exact comparisons.

c. The following ratios were tabulated:

(number of life form responses)/(number of all responses)

(number of correct life form responses)/(number of all responses)

(number of generic responses)/(number of all responses)

(number of correct generic responses)/(number of all responses)

(number of correct life form plus correct generic responses)/number of all responses)

(number of generic responses plus described life form responses)/(number of all responses)

(number of simple* life forms)/(number of all responses)

* Note: simple life form = life form that is not accompanied by a description

The summation of the responses from the slide sets and the outdoor sessions has been included in Appendix A-6.

7. Types of errors: Using the results from the above analysis, inferences were made about the types of errors students made in naming plants. A list was compiled of all the species seen on more than one occasion (in slides, sorting task, or during the two field interviews). Using the domain analysis of strict inclusion, the informant's names for each species were documented. The domain analysis was also reviewed for cases in which the same name was used for more than one species.

Inferences were made about the informant's (a) abilities to recognize the same species in different settings, (b) tendencies to overdiscriminate (use different names for the same species, see Appendix A-7), and (c) tendencies to overgeneralize (use the same name for different species, see Appendix A-8).

8. I reviewed the listing tasks and answered the following questions:

a. For which categories (<u>tree, bush</u>, et cetera) did each informant have the most number of

included plant names?

b. What types of plants were in each list? For example, possible groups might be economic plants, ornamentals, or wild plants. The verbatim transcript for one informant has been placed in Appendix C-2. A summation of the types of names used by all informants is in Table 4.

9. The outdoor sessions and concept mapping exercises were reviewed for each informant's interpretations of the function of plant parts and the informant's names for plant parts, the informant's conception of human dependence on plants, and other abstract concepts.

Stage Two: Textbook Review

Detailed descriptions of the procedures for the textbook review have been included in the following pages. To examine botanical concepts found in the science textbooks used by students in central Texas, a textbook analysis was conducted. I reviewed the elementary textbook series *Science*, Silver Burdett, 1985, and the seventh grade text, *Life science*, Macmillan, 1986.

Objectives of the Textbook Review

1. Document botanical concepts in the textbooks for comparison with the informants' explanations of the concepts.

2. Evaluate the extent to which the science textbooks reflected the recommendations for science education made by the NSTA and the AAAS.

Procedures for the Textbook Review

1. All botany related propositions found in the first through sixth grade texts were documented (Appendix B-1). A proposition is a concept that includes two or more concepts that are linked semantically. For example, "bud" and "flower" are both concepts. "Buds become flowers" is a proposition.

2. The major botanical topics covered in the seventh grade text were documented (Appendix B-7).

Analysis of the Textbook Data

1. Discourse analysis: The researcher reviewed the botanical propositions in search of patterns, relationships, and inconsistencies. As a result, the following lists were compiled and the following aspects of the text were evaluated.

2. A list was made of all the names for plants and plant categories found in the first through six grade texts (Appendix B-2).

3. A list was made of all botany related vocabulary found in the first through sixth grade text (Appendix B-3).

4. Concept maps: The researcher developed concept maps for plant related concepts and propositions found in grades one through six (Appendix B-4). The concept maps provided data for analysis of concept development, complexity of the text, and pedagogical emphasis of the text.

5. Analysis of language of the text - botanical vocabulary: The researcher classified all botanical vocabulary into two groups: Names for plants (maple tree, conifer, vine) and terms for botanical concepts (leaf, photosynthesis, flower). Some labels were classified under both headings: for example, the textbook used "flower" to refer to a part of a plant and to refer to a plant category. The researcher designated names for plant categories (e.g., tree, bush) as both "Names for plants" and "Terms for botanical concepts." Specific and generic plant names were designated only as "Names for plants." (Rationale: "tree" is a fairly abstract concept requiring numerous examples to be adequately defined, whereas the generic name "maple tree" can be reasonably well defined by one illustration.)

a. Names for plants: The researcher classified the "Names for plants" as either familiar or unfamiliar (Appendix B-2). She tallied the percentage of unfamiliar plant names used in each grade (Table 14). Any agricultural plant that is readily available in groceries or grown in Texas and any wild or ornamental plant that commonly occurs in central Texas was designated "familiar". As the plants appear in the child's local environment, the potential exists for the child to recognize these names.

b. Terms for botanical concepts: Terms for concepts were designated as either folk terms or scientific terms (Appendix B-3). The researcher counted the scientific terms related to botany newly introduced in each grade (Table 15). Folk terms were those commonly used in the adult vernacular, terms to which the child is likely to be exposed outside of the school setting. Scientific terms are those not commonly used in the vernacular, terms the child will be likely to encounter only in an educational setting. For example, "sprout" is a folk term, but "germinate" is a scientific term.

c. Vocabulary definitions: The researcher classified the "Terms for botanical concepts" as "Defined by text" or "Not defined by text." Terms not defined were classified as one of the following: "Poor verbal definition," "Defined by illustration only," or "Not illustrated, not defined."

To receive the designation "Defined," the concept must be explained verbally (and often, visually, as well) in a manner that is not in conflict with a scientist's understanding and that portrays enough information for the reader to be able to recognize new examples of the concept. A poor definition may include false or misleading information, or the concept may not have been illustrated adequately to allow the reader to recognize new examples of the concept. For example, the text referred frequently to "cactus" without defining the concept verbally. Illustrations of only two species of cactus appeared in the text, thus, the reader cannot be expected to recognize other

types of cacti based on the information provided in the text.

The researcher then tallied the percentage of terms not defined in each grade (Table 16). A summary list was compiled of all terms that have been defined and those that remain undefined throughout the elementary science series (Appendix B-3).

6. Concept development in the text: the textbook development of botanical concepts was evaluated. The following aspects of the textbook were analyzed.

a. Connections between concepts: the concept maps were used to evaluate how well the text made explicit connections between interrelated concepts.

b. Levels of complexity: The concept maps were used to examine the number of hierarchical levels used in developing each concept.

c. False and misleading statements: examples of false and misleading statements in the elementary textbooks were documented (Appendix B-5).

d. Repetition: repetition of botanical topics was documented for grades one to seven (Appendices B-6, B-7).

e. Abstract versus concrete propositions: The researcher and two additional coders classified the propositions (statements such as "Green plants make their own food") as either abstract - concepts lacking a physical referent, or concrete - concepts having a physical referent. Appendix B-1 lists all the botanical propositions with codes (A = abstract, C = concrete). The researcher tallied the percentage of abstract concepts per grade (Table 17).

An example of a concrete proposition is, "In autumn, leaves change from green to red, gold, or brown." One can see the leaves change. One cannot see the cause of the change. An explanation of the cause of the change would be abstract. One cannot see plants carry out photosynthesis, so "photosynthesis" is also an abstract concept.

The two additional coders were a male adult zoologist with a background in botany, and a 12 year old female student, late in the summer after her sixth grade. The adult read through the list and marked the statements on his own. To assist the student in completing the task, the researcher read the statements out loud and asked the student to say whether the statement referred to "something you can see and touch" or whether it referred to "something you cannot see or touch; something you have to imagine."

Inter-rater agreement between the researcher and the student was 81%. Agreement between the researcher and the zoologist was 79%. In discussing some choices made by the zoologist, it was found that he designated categories such as "tree," as abstract, whereas the researcher and student designated plant categories as concrete. Thus, the male coder designated more statements as abstract than did the student or the researcher. The student tended to designate

more concepts as concrete than did either adult coder.

f. Textbook concept development was compared to student interpretations of concepts.

7. Based on the above analyses, the pedagogical emphasis of the text was evaluated.

CHAPTER IV - INTERPRETATION OF DATA

Chapter IV has presented the interpretations of the data. The chapter has been divided into four sections. Section 1, "Categories for Plants," has reported the componential analysis of the major plant categories. Section 2, "Children's Plant Classification Schemes" has reported the taxonomic analysis. Section 3, "Names for Plants," has provided an analysis of the types of responses the children gave when asked to name plants. Section 4, "Textbook Concepts Compared with the Conceptions of the Child," has the textbook review.

Much of the raw data has been placed in the appendices. In an attempt to differentiate between interpretations made directly from the raw data and those that were more speculative in nature, the interpretations of the data have been presented as level 1, 2, and 3 assertions. Level 1 assertions are inferences made directly from the raw data. These often include tables that sum up the raw data. Level 2 assertions are one step removed from the raw data. Level 3 assertions are generally speculations about the meanings of the data and include implications for research and education. Each section ends with a summary of the level 2 and 3 assertions. Chapter V has a comprehensive summary of the assertions and adds further speculations on the meaning and implications of the research.

Section 1: Categories for Plants

Introduction

Componential analysis was used to examine the following questions: what major plant categories does the child use to classify plants; how does the child define those categories? Both the componential analysis and the taxonomic analysis were used to examine the following questions: how do the child's categories relate to each other hierarchically; what level of abstraction is salient for the child when naming plants. These final questions have been addressed in later sections of Chapter IV.

In the domain analysis of strict inclusion, I have summarized the informant's names for plants and the named and unnamed members of each plant category. In the domain analysis of attribution, I have summarized the informants' statements about how to differentiate between plant categories. The level 1 assertions that form the domain analysis of strict inclusion for one informant have been placed in Appendix A-3. The level 1 assertions that form the domain analysis of attribution for one informant have been placed in Appendix A-4. These analyses were used in the development of the componential and taxonomic analyses, therefore these secondary analyses begin with level 2 assertions.

The componential analysis was used to develop theories of the informants' meanings for their major plant categories. It was also used to examine the taxonomic relationships between

categories and the basic level of abstraction used for naming plants. Berlin's research provided the model for the taxonomic classification of each folk category (see Figure 1).

The major plant categories analyzed were plants, trees, bushes, flowers, grass, vines, cactus, weeds, leaves, and fruits and vegetables. Dictionary definitions for these terms may be found in Appendix A-9 (from the American Heritage Dictionary). Two informants used all categories. Seven informants used all categories except leaves. Other categories mentioned by the informants (e.g., ferns and fungus) were not used often enough to allow for analysis.

Each major plant category used by the informants has been examined separately below, with a summary of the data given at the end of section 1. For each plant category, the following were examined: the taxonomic classification for the category (based on Berlin's model), the salience of each category relative to other categories, the level of abstraction that is basic for naming members of that category, the criteria used for category membership, overlapping categories, and comparison of children's meanings with adult meanings for the category.

I used the informants' statements about how to recognize a bush, flower, et cetera, as a key indicator for which criteria were important for category selection (see domain analysis of attribution, Appendix A-4). If informants gave few or no statements about attributes of the categories, I have inferred the criteria, based on attributes of the category members.

Categories for Plants: Level 2 Assertions

Plants

       Taxonomic classification.

For eight informants, plants was polysemantic (had multiple meanings). Six informants recognized that plants could include trees and bushes. For these informants, plants served as a unique beginner but not consistently. With the exception of informant 9 (for whom plants did not appear to be polysemantic), the students rarely used plants in an all-inclusive manner.

When asked to list the categories of plants, six informants included trees but several stated that they did not believe trees were "real plants." With the exception of informant 9, all typically used plants in reference to herbaceous plants. When used in this manner, plants was not a unique beginner. It may have served as a life form at level 1.

At least five informants (1,3,5,7, and 8) appeared to use plants at an intermediate level above the life form level, with several major herbaceous categories (e.g., grass or flowers) as subsets. These informants demonstrated a tendency to divide all plants into two broad categories, large woody plants versus small nonwoody plants. Some label these intermediate categories. For example, informant 1 appeared to divide her specimens into either trees or real plants. For others the intermediate category is covert, unnamed.

The category real plants did not qualify as a unique beginner because it did not include trees. Nor did it qualify as a life form because included within it was the life form (labeled by a primary lexeme) flowers, which included within it some generic names (primary lexemes) that were terminal. The two divisions, trees and real plants shared the top level of the hierarchy, thus they may be thought of as pseudo-unique beginners. Informant 3 used the pseudo-unique beginner flowers and plants to include almost all flowering and non-flowering herbs. Refer to Figures 4-14 for the models of the informants' folk classification schemes.

Seven informants included herbaceous specimens as plants most of the time. All informants also appeared to use the category as a residual part of the time. A residual category acts as a catch-all for otherwise unclassified specimens (refer to section 2, "Children's Plant Classification Schemes" for a discussion of residuals). Plants appeared to be commonly used to place unusual specimens that were neither clearly herbaceous nor woody (such as cacti or yuccas). For example, six informants placed at least one yucca, agave, or cactus in this category. A few informants placed some ferns or the dwarf palmetto in the category.

Of the three informants who did not recognize that trees are plants, one (informant 8) changed her concept later in the interviews. The two others (informants 3 and 7) were among those with the largest number of consistent and botanically acceptable categories. For both, the plant category may be in transition, on the verge of expanding to a unique beginner. Whether or not the polysemous usage will then disappear is subject to some doubt (see discussion of adult meanings for the category).

Salience of the category.

All nine informants used plants as one of their major categories. Seven used it as a primary category in the sorting task. Thus plants was a meaningful category for the children. All informants used the category less frequently than the category trees. Eight informants used the category plants less frequently than the category flowers. Thus the category seemed to be less salient than flowers or trees.

Four informants called fewer than 15 specimens plants. The label was rarely used by the three informants (5, 6, and 9) who appeared to have the best understanding of plants as an all-inclusive category (unique beginner). The category was used frequently only by those three informants (3, 7, and 8) who did not recognize that a tree can be a plant.

As a residual, the category plants was used more frequently than the grass, weeds, and leaves categories, that usually were restricted to herbaceous specimens.

C.H. Brown (1984) called the category of herbaceous plants grerb and found that most languages have a label for such a category. In the English language, Brown believed that grerb was equated with plant. He has considered the grerb category to be one of the most salient plant categories, possibly encoded early in the development of life form terms (second in importance after trees).

Brown did not take into account the division of herbs into flowering and nonflowering herbs, thus the possible importance of the category <u>flowers</u> is not accounted for in Brown's model (Figure 2).

<u>Basic level of abstraction for naming plants.</u>

Four informants used the category <u>plants</u> fewer than 15 times. The preference for the categories <u>flowers</u> and <u>trees</u> may have indicated a desire to use a less abstract category for naming specimens.

About 30% of the specimens classified as <u>plants</u> were named at the generic level. Typically, named specimens were included in a less abstract subset, such as the intermediate category <u>water plants</u>. Within these subsets, most specimens were named with primary lexemes, thus the generic level was linguistically salient and was preferred over the suprageneric label <u>plants</u>. Some informants did make up generic names (e.g., <u>thorn plant</u>), but outside of the subsets specimens were rarely named at the generic level. When used as a residual, therefore, the suprageneric level was salient.

<u>Criteria for category membership.</u>

Only informant 9 defined <u>plants</u> in a scientifically acceptable manner, relying on reproductive characteristics ("It grows and has seeds that fall into the ground and make another one"). No other informant verbally defined the category in a manner that would include woody plants, such as trees and shrubs.

Three informants referred to "greenness" as a key characteristic of <u>plants</u> ("They're all green most of the time."). Small size and lack of showy flowers were also important criteria for category membership. For all informants, 60-95 percent of the specimens selected fit the criteria of being green all over, having a small size, and lacking flowers.

The category <u>plants</u> appeared to be monothetic, relying on a few critical (necessary and sufficient) criteria for category membership. In the sorting task, of the seven informants who used <u>plants</u> as a primary category, all but one included virtually all the herbaceous plants without flowers. Several informants included some herbs with non-showy flowers, but no one included any herbs with colorful, showy flowers. Five informants included some grasses.

The informants' verbal statements indicate that the prototype <u>plant</u> was a small, green (i.e., non-flowering) herb. Some deviation from that prototype was allowable, however. Greenness appeared to be more important than size in category selection. Seven informants included some large green plants (neither herbaceous nor woody) in the category. Informant 7 may have used the criterion "green all over" as a single critical criterion, allowing cacti, yuccas, agaves, and ferns to be admitted to the group. For informant 6, <u>plants</u> tended to be restricted to non-wild herbs, particularly house plants.

While the category was based on structural criteria, the presence or absence of flowers can be seasonal, thus the category <u>plants</u> was unstable. If a flower appeared, a specimen was likely to be

moved to the category <u>flowers</u>. In addition, residual usage resulted in a category that was somewhat subjective. Eight informants included one or more woody plants (e.g., rose bush or azalea) in the category.

For virtually all informants, whether they used the category as a life form, intermediate, or residual, specimens seemed to make it into the category by default - if it didn't have flowers, was not brown/woody, or didn't have thorns, it was a <u>plant</u>. For example, in the sorting task, a railroad vine was viewed both with and without flowers. Most informants included the flowering vine with <u>flowers</u>, and five informants included the non-flowering vine with <u>plants</u>.

      <u>Overlapping categories</u>.

The category <u>plants</u> never exhaustively sorted all the small, non-flowering herbs. A few always made it into one of the other herbaceous categories. Informants rarely made the mistake of placing an herb in one of the woody plant categories, <u>tree</u> or <u>bush</u>.

There was much overlap between the herbaceous categories, <u>plants</u>, <u>flowers</u>, <u>weeds</u>, <u>grass</u>, and <u>leaves</u>, with no gradation of criteria from one to another. A non-flowering herb might be classified in any of several herbaceous categories. Flowering herbs, while usually considered <u>flowers</u>, occasionally were classified as <u>weeds</u> or <u>plants</u>. In those cases, the subjective criterion of "prettiness" may have been an additional factor. Criteria for distinguishing the herbaceous categories was somewhat subjective, resulting in unpredictable selections between the herbaceous categories.

The alteration of a single criterion (such as emergence of flowers, or change in size) tended to throw the specimen out of one category and into another, thus the categories were sometimes dependent on unstable criteria. For most informants, for example, the addition of showy flowers would throw a <u>plant</u> into the <u>flowers</u> category. For informant 7, the green part of a plant was the <u>plant</u> and the rest of the plant was designated differently. For example, he called the green flower stalk of a yucca a <u>plant</u>, while the leaves were a <u>bush</u>.

In his comparison of data from 188 languages, C.H. Brown (1984) found that the <u>grerb</u> category could include grasses, but that when a culture encoded both <u>grerb</u> and <u>grass</u>, the category <u>grerb</u> tended to include only non-grasses (p. 118). In this study, four informants included <u>grass</u> as a subset of <u>plants</u>, and six included some grasses (but never all the grasses) in their selections of <u>plants</u>.

      <u>Intermediate categories</u>.

All the informants had at least one intermediate category under the herbaceous category <u>plants</u>. Informant 7, for example, has divided <u>plants</u> into several major subsets: <u>grass</u>, <u>flowers</u>, <u>vines</u>, <u>cactus</u>, <u>plants in or at a house</u>, <u>plants that float in the river,</u> and <u>wild plants</u>. <u>Plants</u> is the only major category that this informant has subdivided with life form labels. While the prototypes for the subsets were herbaceous, some of the subsets (<u>vine</u>, <u>flowers</u>) included a few woody plants,

and the informant recognized that some of the things he called cactus were like trees. The informant might have been on the verge of recognizing that trees and bushes could be plants.

For three informants (1,2, and 4), water plants was an important subset of plants. This may have been related to two factors: the recreational importance of a spring-fed river in the town, and the fact that one sixth grade science teacher used local aquatic plants as examples in her plant unit. For these informants, water plants appeared to have greater salience as a category than plants. Most of the water plants had generic names, and an aquatic plant with a flower was just as likely to be called a water plant as a flower. The category, however, was monothetic (relying on the presence of water alone) and unpredictable. While the prototype water plant was herbaceous, some informants included a few woody plants, even trees in the category by virtue of their proximity to a body of water. Sorting was not exhaustive as some aquatic plants were found in other categories as well.

	Adult meanings.

The dictionary definition of plant is "any organism of the Kingdom Plantae, characteristically having cellulose cell walls, growing by synthesis of inorganic substances, and lacking the power of locomotion." Plants is an inclusive category that includes both woody and herbaceous forms. The informants' use of the category plants did not match that of the dictionary or a botanist. Only informant 9 gave a botanically acceptable definition based on reproduction.

A botanist would consider the children's use of the category indicative of misconceptions about plants. One might expect that the polysemantic use of plants would be developmental, that each of these informants would eventually use the term in an all-encompassing manner exclusively. Nonetheless, C.H. Brown (1984) found that English speaking adults tend to use plants in a polysemous manner, very similar to the usage of the children in this study. He reported that some English speaking adults use the term strictly in reference to herbs (p. 65). As additional anecdotal evidence, I have conversed with several adults that unconsciously used plants in reference to herbs.

C.H. Brown (1984) found a term referring to small herbaceous plants in virtually all languages he examined. Brown found that English speaking adults commonly use plants in reference to herbs, and that they sometimes extend the category to include grasses, some shrubs, and herbaceous vines. Thus, the children in this study apparently have grasped the meaning of plants as it is commonly used in the adult vernacular.

The elementary textbooks examined gave illustrations of a wide variety of types of plants, including trees. I developed concept maps of the concepts in the textbooks (refer to Appendix B-4). In several grades in the textbook, the concept tree was not connected to the concept plants. Starting in first grade, the text used plants as a unique beginner, at the most abstract level of the taxonomic hierarchy. The differentiation of plants into various subsets (trees, vines, shrubs, and herbs) was not introduced until grade three.

The text stated that plants are living things; they have roots, stems, leaves, and other parts; they can have many shapes, be big or small, and have hard or soft stems. In grade three, the seed plants were divided into four categories based on type of stem: tree, shrub, herb, and vine (a folk classification scheme). In grade four, plants were divided into groups based on how they reproduce: seed plants and non-seed plants (a scientific classification scheme). Seed plants were divided into conifers or flowering plants. No attempt was made in the text to explain the disparity between these two types of classification schemes. The children do not share the meaning for plants depicted by the text.

Trees

Taxonomic classification.

The informants used the category tree at level 1 (see Figures 4-14). For all informants, the category had numerous named members. The names of the included members were primary lexemes (generic names, e.g., maple, pecan) and often were terminal. Thus tree qualified as a life form using Berlin's model (see Figure 1).

Four informants (5,6,8, and 9) divided tree into intermediate categories, based on leaf type (trees with broad leaves or needles). Two used the terms conifer and deciduous. For two, tree referred to non-conifers and the category pine tree or evergreen or pine trees and coniferous was distinguished from trees. The intermediate categories always include named generics (primary lexemes at level 2). For five informants, tree may have been perceived as in binary opposition to plants, the two categories referring to large woody plants and small non-woody plants respectively. When used in this manner, I have suggested that tree and plant act as pseudo-unique beginners as they share the top of the hierarchy.

Salience of the category.

All informants placed more plant specimens with trees than with any other category. Numerous members were named at the generic level. Category selection was consistent. Along with flowers, vegetables, and fruits, this was one of the most salient life form categories for all informants.

In ethnobotanical studies in other languages, tree has been found to be the most salient category. C.H. Brown (1984) has suggested that tree is encoded first in the development of life form categories (p. 115).

Basic level of abstraction for naming trees.

For six informants, more than 40% of the trees had generic names, primary lexemes at level 2 (refer to Figures 4-14). Most informants would either make up a name or add descriptive information to the life form label in preference to using the abstract label alone. Thus generic names were salient for naming trees.

<u>Criteria for category membership</u>.

There was a high level of agreement between informants about what specimens were <u>trees</u>. In the sorting task, all informants included virtually all specimens in the first four groups of woody plants as <u>trees</u>, the same specimens as chosen by the researcher (refer to Appendix A-2 for a list of the groups of plants in the sorting task).

Height (taller than a person) and the presence of a large visible trunk or trunks were the most important criteria for recognition of a <u>tree</u>. Though most specimens had single, large trunks, multiple trunked live oaks, mesquites, and junipers were among the "most typical trees" chosen by several informants.

In the sorting task, the consistent inclusion of a juniper that was taller than a person and had visible trunks, and the consistent exclusion of a juniper with trunks hidden by leaves indicated the importance of height and visibility of trunks over the number and diameter of the trunks. The exclusion of palms when their trunks were hidden by dead leaves may indicate the importance of the visibility of the trunks to category selection.

Other characteristics were secondary in importance. Most children commented that tree trunks are brown, though few mentioned that trees are woody. Although woodiness was a salient criterion, some non-woody plants with treelike form could be included. Eight informants included an agave with a tall flowering stalk as a <u>tree</u>, indicating that height and presence of a large trunk outweighed brown trunk color (i.e., woodiness) in importance.

While needle-bearing trees were recognized as <u>trees</u>, some informants placed them into a separate category (see Figures 4-14). The inclusion of agaves and yuccas could signify that the informants allow a wide variety of leaf types among <u>trees</u>. There was evidence that several informants did not recognize the leaves of agaves and yuccas, however. The informants may have thought that these specimens were leafless.

Though all informants placed at least one flowering woody plant (redbud tree) with the <u>trees</u>, several informants stated the belief that trees do not have flowers. This notion may have influenced the fact that flowering woody plants were often placed in a different category, either <u>flowers</u> or <u>bushes</u>.

The informants' verbal statements indicated that the prototype tree was a broadleaf deciduous tree with a tall trunk (either single or multiple trunks) and spreading branches elevated some distance from the ground. Actual selections allowed greater variability among focal (prototypical) members, with conifers and palms sometimes included.

Classification of <u>trees</u> was based on polythetic criteria, that is trees were distinguished by a variety of features. No single criterion (not even woodiness) was necessary or sufficient for category membership. Rather, membership appeared to be dependent on family resemblance. The specimens shared one to several criteria with the prototype. Thus the prototypical tree provided

an image against which the informant could judge the degree of "treeness" of a specimen. Those specimens designated as "most like a tree" shared several criteria with the prototype. All members shared at least one important criterion with the prototype (such as large size or large trunk), but no criterion was shared by all members.

Tree was always a consistent category, with predictable members. Most informants sorted the category exhaustively or nearly so. Few if any large woody specimens were omitted.

The criteria the informants used to classify trees were structural, not subjective. While some criteria (size, height of crown) vary between species or depend on age of the specimen, most criteria do not change seasonally. Something that was a tree this year would still be a tree next year, thus the criteria were fairly stable.

Informant 4 overdiscriminated the trees, omitting trees with flowers and trees by the water in his general category. Four informants overgeneralized somewhat, placing a few woody vines, shrubs, or bushy herbs in the category.

Overlapping categories.

In nature, a number of woody species vary in form from treelike to bushlike. One specimen of a species may resemble a tree while others are more like bushes. Some specimens share criteria of both. Most informants were aware that such specimens (e.g., junipers) could be called either trees or bushes.

Species that shared few criteria with the prototype typically appeared in more than one category and were designated "least like a tree." For example, agaves with trunk-like flower stalks and trunk-bearing yuccas or cacti were often included with trees but were almost always designated "least like a tree." While the flower stalks resemble tree trunks, these specimens do not have woody, brown trunks or typical leaves. Different specimens of yuccas and agaves often fell into more than one category, either trees and plants or trees and cactus. Woody plants with slender multiple trunks tended to be designated "least like a tree" or "sort of like a tree."

A gradation of criteria occurred between the tree and bush categories, the only woody plant groups. Specimens on the fringes of one category might be placed arbitrarily in either or both groups. If the plant had small multiple trunks, it was more likely to be called bush than tree. Specimens that some called bushes (with multiple slender trunks), however, might be called trees by others if the trunks were not hidden by the leaves or if the specimen was taller than a person. Some informants placed woody vines (e.g., grape, wisteria) with the trees. This may have reflected a tendency to call all woody plants trees.

Informant 4 placed some trees in the categories "trees with flowers" and "plants and trees by the water." Though this might be seen as an attempt to break the category into smaller, less abstract groups, the selections were inconsistent and the sorting was not exhaustive. This informant had quite a bit of inconsistent classification frequently using backgrounds in photographs (e.g., a red

sunset) as a basis for classification rather than features of the plant itself.

<u>Adult meanings.</u>

<u>Tree</u> is a folk category that is recognized by both adult laymen and botanists. Though botanists do not use it as a scientific plant category, they use the category descriptively.

With the exception of those who overgeneralized, five informants had category members for <u>trees</u> that would be acceptable to a botanist. Thus there was evidence that these children grasped the meaning for <u>trees</u> as viewed by a botanist.

Ethnobotanical studies have demonstrated that a label equivalent to the English <u>tree</u> appears in virtually all languages (C.H. Brown, 1984). The category typically has included the most number of named classes. The category often is extended to woody shrubs and sometimes to woody vines. It sometimes included large non-woody plants (e.g., cacti). Thus even when overgeneralizing, the children in this study have used the category <u>trees</u> in a manner very similar to that of the adult layman in other languages. The English speaking adult may be found to overgeneralize in a similar manner.

The dictionary definition for <u>tree</u> is "a usually tall woody plant, distinguished from a shrub by having comparatively greater height and, characteristically, a single trunk rather than several stems." The definition has implied that these are the necessary and sufficient conditions for category membership in <u>trees</u>. Rather than giving the meaning of the concept <u>tree</u>, the dictionary has apparently presented a description of the prototypical tree, not allowing for the great diversity of form present among trees (some trees are small, some have several trunks). The informants' verbal statements also tended to describe only the prototypical tree although their selections indicated a tolerance for a much wider range of specimens.

The elementary textbooks analyzed used the category frequently and provided numerous visual examples. Statements in the textbooks about trees presented a restricted image of trees. The text stated that trees have one main trunk. Other characters presented in the text match those used by the students - presence of wood, bark, leaves, and branches that make a roof over the ground. Even though the text included illustrations of conifers as examples of trees, textbook statements portrayed the same prototype as that of the informants, a broadleaf deciduous tree.

The text separated trees into those with broad leaves and needles and provided good visual examples of needle-bearing trees. Though the text used the terms <u>conifer</u>, <u>deciduous</u>, and <u>evergreen</u>, it did not accurately define <u>deciduous</u> and <u>evergreen</u>. The text perpetuated the common adult misconception, also found among the students, that all evergreens are conifers and all broadleaf trees are deciduous.

Bushes

Taxonomic classification.

The informants generally used the category <u>bush</u> at level 1 (refer to Figures 4-14). Three informants used a mixture of primary and secondary lexemes for the named members. For these informants, the category <u>bush</u> qualified as a life form category using Berlin's linguistic guidelines. Five informants used all secondary lexemes to name the members (e.g., <u>rose bush</u>, <u>thorn bush</u>). Using Berlin's guidelines, the category <u>bush</u> could be a generic for those informants. I have assumed that <u>bush</u> served as a life form as most informants seemed to place it in binary opposition to <u>trees</u>. For further discussion, refer to section 2, "Children's Plant Classification Schemes."

In cases where informants tended to divide plants into only two categories, either explicitly or implicitly <u>trees</u> and <u>plants</u>, the category <u>bushes</u> generally seemed to be included with the pseudo-generic <u>trees</u> (refer to Figures 4-14). The inclusion of bushes with trees was at times ambiguous, however. For example, Informant 1 stated that bushes seem to be "half plant, half tree."

The hierarchical placement of <u>bushes</u> seemed somewhat ambiguous. This may have been due to the tendency of six informants to use <u>bush</u> as a residual category, a dumping ground for otherwise unclassified specimens. The dearth of named members and the inconsistent category selection both indicate residual usage. These informants included some grasses, cacti, aquatic plants, ferns, and yuccas as <u>bushes</u>.

Salience of the category.

All nine informants used <u>bush</u> as a primary category in the sorting task, perhaps signifying that it is not solely a residual category. Only three informants used the category frequently. The category was not as consistent as <u>trees</u>. While every informant placed a few woody plants with slender multiple trunks in the <u>trees</u>, very rarely did they call any woody plants with single trunks <u>bushes</u>. The category clearly did not have the salience of the <u>tree</u> category.

C.H. Brown (1984) has suggested that in various languages <u>bush</u> was encoded relatively late in the development of life form categories. He has speculated that it always appears after <u>tree</u> and typically after <u>grerb</u> and <u>grass</u>. Thus the category <u>bush</u> may be secondary in salience in many cultures.

Basic level of abstraction for naming bushes.

The informants had few generic names for bushes and did not mind calling a specimen "just a bush." The generic level was not linguistically salient. The life form may have been preferred for naming bushes.

<u>Criteria for category membership</u>.

Overall form, color, and size appeared to be the most important criteria for designation of bushes. A rounded "bushy" shape, overall greenness (the crown of leaves surrounding the trunks), and relatively small size (shorter than a person) were the typical characteristics of bushes.

For seven informants, the verbal statements described a similar prototypical <u>bush</u>. The prototypical bush appeared to be the trimmed, rounded hedge, such as that seen in many home landscapes. The prototype was small, and had closely packed leaves that surrounded and hid the trunks. In the sorting task, all but one informant selected such a hedge as an example of a bush, and in the field, trimmed hedges around the informants' homes were almost universally called <u>bushes</u>. It was notable that the verbal prototype was consistent even though informants varied widely in their category selections.

<u>Bushes</u> often had multiple trunks branching from the base (although the trunks were hidden the informants knew they were supposed to be there). The inclusion of various non-woody plants with a rounded or bushy shape (e.g., some grasses and ferns) provided evidence that overall shape was more important than woodiness in category selection. Non-woody plants could even be included among those specimens considered "most like a bush." For five informants all members selected in the sorting task had the rounded, bushy form.

Though I did not consistently ask informants to designate those bushes "most like a bush" and "least like a bush," two informants carried out that task. The responses of informant 2 showed that for her, rounded form was more important than greenness in category selection. Woody shrubs and bushy ferns were "most like" and cacti were "least like a bush."

Four informants included some treelike yuccas and treelike cacti as <u>bushes</u>, possibly indicating that greenness could equal shape and size in importance (although these selections might only signify residual usage).

The common exclusion of a juniper with visible trunks and inclusion of a palm tree with hidden trunks indicated that the informants might expect the trunks of bushes to be hidden by the leaves. Verbal statements validated the importance of this attribute.

Other criteria might also have been important to classification but were secondary. The trunks were often brown, very slender, and typically short. Few informants mentioned that <u>bushes</u> are woody. While woodiness might have been a salient criterion for some, for four informants in the sorting task non-woody plants outnumbered woody plants among the <u>bushes</u>.

Specimens that informants selected as <u>bushes</u> usually had small leaves and could have either broad leaves or needle-like leaves. <u>Bushes</u> could have flowers but the presence of flowers often threw a specimen into the <u>flowers</u> category.

For informants 8 and 9 (and possibly others) bushy form and overall greenness may have been

used as monothetic critical criteria, allowing an odd assortment of non-woody plants (bushy grasses, cacti, ferns, and yuccas) to be included. For these informants the category was overgeneralized. For informant 4 the category was restricted to just a few woody specimens that closely matched the prototype trimmed ornamental shrub.

In the sorting task, only three informants included most of the woody shrubs as <u>bushes</u>. Five selected only one or two woody shrubs. The shrubs that were commonly excluded were the flowering shrubs and those with visible trunks.

The inclusion of such an odd assortment of plants resulted in unpredictable category membership. Inconsistencies made it difficult to determine whether these informants used polythetic or monothetic criteria in category selection, or whether most of their selections were residual. Certainly, the residual nature of the category adds to the unpredictable nature of category selection.

For a few informants (1,3,7, and possibly others), the category may have been polythetic, relying on a family of criteria for membership rather than a single or a few critical criteria. Their category selections, mostly woody shrubs, were more consistent with a botanist's selections of <u>shrubs</u>. The terms <u>bush</u> and <u>shrub</u> are not scientific terms but are often used both by botanists and the layman.

The criteria for <u>bush</u> were structural, but the criteria used for category selection may be somewhat subjective. The criteria (overall rounded shape, size, and greenness) were generally stable. Most <u>bushes</u> would not change much from season to season. Some informants might reclassify bushes as <u>flowers</u> during the flowering season.

   <u>Overlapping categories</u>.

As with the <u>trees</u>, the <u>bush</u> specimens that shared few of the prototypical characters tended to appear in more than one category. Overlap occurred most commonly with the <u>trees</u>, with a gradation of criteria ranging from one to the other category (size, number and size of trunks, height of crown).

In nature woody plants vary considerably in form, with different specimens of a species taking on either bushy or treelike forms. All informants except number 6 placed different specimens of some species in both <u>bush</u> and <u>tree</u> categories, and most were aware that some specimens could be called either <u>tree</u> or <u>bush</u>.

The <u>bush</u> category was never exhaustively sorted. A few woody specimens with numerous slender trunks branching from the base always appeared in the <u>tree</u> category, and a few frequently appeared in the <u>flowers</u> category. And some non-woody plants with bushy form were frequently included as <u>bushes</u>.

Agaves and yuccas do not have brown, woody trunks or typical leaves, but as they are not

herbaceous they were frequently placed with either the trees, bushes or cactus categories. These unusual species matched the prototype bush on two criteria. The non-flowering agave was green and had an overall rounded shape. This shape, while not resembling the prototypical bush, was quite different from the treelike appearance of the agave in bloom.

Adult meanings.

Bush is a folk category, familiar to adult laymen and botanists. Though not a scientific category, the bush category is used by botanists descriptively.

The informant's verbal statements about bushes closely resemble the botanist's use of the category shrub. The dictionary definition of shrub is "a woody plant of relatively low height, distinguished from a tree by having several stems rather than a single trunk; a bush." The terms bush and shrub are inter-changeable but bush is more commonly used by the layman and shrub is more common for a botanist.

Because most informants either overdiscriminated and/or overgeneralized bushes, the category was usually not botanically accurate. For many specimens, however, a botanist would agree with the informants' classifications. Accurate selection of woody shrubs indicated that three informants had grasped the meaning of bush as it would be used by a botanist. Most informants had only a partial grasp of a botanist's meaning of the concept. As Kempton (1981) pointed out, the fact that the informants had a similar prototypical bush would enable them to communicate with adults without difficulty.

A term equivalent to bush is found in virtually all cultures studied (C.H. Brown, 1984, p. 13). Adults in various cultures used the category to refer to bushy plants smaller than trees. Brown found that the "encoding of bush... involves pulling bushes from the range of grerb or tree, or from the ranges of both" (p. 118).

Among English speaking adults, Brown found a tendency to extend bush to include "thick disorganized growth" (p. 200). Thus it may be that the children in this study have used the category bush in a manner similar to that of the adult layman.

Only informant 9 used the term shrub. He stated that a shrub is a miniature bush, and the only shrubs he pointed out were small trimmed ornamental shrubs in front of his house. In a study of English speaking adults, C.H. Brown (1984) found a tendency among some adults to use shrub in a restricted sense in reference to ornamental shrubs.

Though the elementary textbook used both terms, it gave the impression that bush is a subset of shrub ("some shrubs are called bushes") rather than an interchangeable label. The text provided few visual examples of either bushes or shrubs.

In the textbook characteristics of shrubs were given only in grade three. The text stated that shrubs are smaller than trees and have many woody stems. While the informants' verbal

definitions agreed with those of text and dictionary, the informants selections of woody shrubs included greater variation than the verbal definition allows. Some shrubs may have single trunks and some are taller than some trees. As with trees the dictionary and textbook definitions of shrub are restricted, portraying a prototype rather than the true diversity of form found in nature.

Flowers

Taxonomic classification.

For these informants, the term flower was polysemantic. It was sometimes used in reference to an anatomical part of a plant and sometimes in reference to a category.

As a category, flower was always used at level 1 (refer to Figures 4-14). The category had numerous named members. The names were primary lexemes, usually terminal. Using Berlin's linguistic guidelines (Berlin, 1976), flowers qualified as a life form.

Informant 3 used flowers and plants as a category that included virtually all herbs. I have referred to this as a pseudo-unique beginner, as it shares the top of the hierarchy with trees (see Figures 4-14).

Several informants divided flowers into the intermediate categories wildflowers and garden flowers. These informants were inconsistent in their intermediate classifications. Some species appeared in both groups. As these intermediate categories were based on human uses rather than morphological differences, the inconsistency was inevitable (a bluebonnet can grow wild or it can be planted in a garden).

Salience of the category.

Flowers was used and members named more often than any other life form except trees. Membership was fairly predictable. All nine informants used flowers as a primary category in the sorting task. The category clearly had more salience than any other herbaceous plant category, as was attested by the unpredictable manner in which non-flowering herbs were distributed in the other herbaceous categories, plants, leaves, grass and weeds.

Basic level of abstraction for naming flowers.

All informants named more than 35% of their flowers with primary lexemes at level 2 (generics). Some informants made up names or added descriptive information to the life form label, thereby avoiding use of the abstract label alone. The generic level of naming was salient for naming flowers.

Criteria for category membership.

For virtually all informants the category was monothetic, that is, membership in the category was

defined by the presence or absence of a single or few criteria for classification. The presence of flowers was necessary for membership in <u>flowers</u> and in some cases was sufficient as well. Herbaceous habit also seemed to be a critical criterion.

The informants' verbal statements and selections indicated a small, herbaceous prototype with an attractive, showy flower. In the sorting task all informants selected nearly all the herbs with showy flowers as <u>flowers</u>. Eight included a few (but never all) herbs with non-showy or weedy looking plants in bloom, indicating that "prettiness" may be an important factor in category selection. Five informants excluded the aquatic herbs. Herbs without flowers were not included except in two cases, when the informant acknowledged that the herb would have a flower later.

In a monothetic category, typically, all members share all of the necessary and sufficient criteria with the prototype, that is, the criteria are critical. If the criteria are altered at all, the specimen is thrown out of the category. It was typical for a flowering herb to be placed in a different herbaceous category if it lacked a flower.

Although most selections were herbaceous, informants were not consistent in their selections. It seemed that the informants vacillated between relying on the prototype (flowering herb) for category selection, and relying on the single criterion, presence of flowers. The result was that some flowering non-herbs (such as roses) were commonly included.

Inconsistencies were inevitable, as the prototype was herbaceous but in fact flowers grow on all types of plants, woody or herbaceous. Sometimes a few cacti, sometimes a few shrubs were added but the category never included all flowering plants. A few flowering woody and herbaceous plants were always omitted.

While the herbaceous prototype predominated in selecting members, several informants stated their knowledge that a wide variety of plants, including trees and bushes, could have flowers. Informant 4 even established a separate category for "trees with flowers." For these informants woody plants with flowers differ from what some informants called "real flowers," that is, herbs. The fact that no informant placed all flowering plants (woody or not) in the category <u>flowers</u> reflected the underlying belief that a <u>bush</u> or a <u>tree</u> is not really a <u>flower</u>. For these informants <u>flowers</u> as a category seemed to be polysemantic, vacillating between the prototypical form and a more all-encompassing form.

Though virtually all members of the category had flowers, vacillation between use of a prototype and use of a single criterion made category selection inconsistent. In addition, the fact that an herb would be moved out of the category when its flowers wilted made the category unstable. Prettiness, as a subjective criterion, added to the instability of the category.

Some unexplained inconsistencies occurred in the category. Two informants added several tall grasses to the group. Though grasses do indeed have flowers, the flowers do not resemble anything that the layman would recognize as a flower. On these particular specimens the flowers were not in evidence. Informant 1 called her grasses <u>wildflowers</u> with no additional comment.

Informant 5 became confused when she discovered what she had done and she changed the name of the category to <u>flowers and grasses</u>.

Informants 2 and 5 added some colorful non-flowers to the category: lichens and red leaves. Several informants made the error of calling a colorful leaf a flower.

      <u>Overlapping categories</u>.

There was a large degree of overlap between <u>flowers</u> and other categories. As in other monothetic categories, the overlap was not due to a gradation of characteristics from one category to the next. Overlap between various herbaceous categories was caused by the instability of the criteria (prettiness is subjective, and flowers come and go). Also, the polysemantic use of <u>flowers</u> caused overlap between herbaceous and woody categories.

The same species would frequently be placed in two different categories, depending on presence and absence of flowers. For example, one informant stated that the buttercup becomes a <u>weed</u> when the flower is gone. A bluebonnet may be classified as a <u>flower</u> in one case and as a <u>plant</u> in another.

If flowers were ignored, there was no discernible difference between this and most other herbaceous categories. Herbs without flowers or with non-showy or unattractive flowers would fall into any of several other herbaceous categories, <u>weeds</u>, <u>plants</u>, <u>leaves</u>, or <u>grass</u>.

Some informants may not have been aware that they placed the same species in different categories. Informant 4 may have believed that when the flower was missing, the specimen actually was a different plant. Some informants were aware of their double classification scheme but were not troubled by it.

Only three informants (3,5,9) placed any non-flowering herbs in the flower category based on knowledge that the plants could have flowers. While not consistently eliminating double classification, these informants appeared to have a basic dissatisfaction with it. They did not have enough information, however, to alter their scheme.

Only one informant, number 3, had developed a composite category that helped alleviate the problem of category overlap. He included virtually all herbs in the category <u>flowers and plants</u>. This informant was the only one to use an all-encompassing herbaceous category that was polythetic and stable.

      <u>Adult meanings</u>.

<u>Flowers</u> is not a valid botanical category of plants. The dictionary defined a flower as the reproductive structure of a seed bearing plant. Though botanists would say that <u>flowers</u> should not be used as a category, they would insist that, if used as a plant category, <u>flowers</u> should include woody plants and grasses.

I have observed that the adult layman in Texas tends to use the term <u>flowers</u> in the same manner as the children in this study, almost exclusively in reference to herbs with showy flowers. One informant stated that her teacher asked the students to make a collect of flowers. The only examples the teacher gave were of herbaceous plants, therefore the student concluded that she had better collect only herbaceous specimens.

C.H. Brown (1984) has considered <u>flower</u> a special purpose class in the English language as it generally refers only to the presence of showy blossoms (p. 10). He stated that adults use the term in reference to any plant with showy flowers, not just herbs. Brown does not consider the use of the category further. I recommend a re-evaluation of the importance of the adult use of the category <u>flowers</u> in reference to herbs.

The usage of <u>flowers</u> as a category label in the adult vernacular is so common that the third dictionary definition for <u>flower</u> is "a plant cultivated or conspicuous for its blossoms." In Texas, <u>wildflowers</u> is the popular layman's term for flowering herbs not found in gardens. Technically, the terms <u>flowers</u> and <u>wildflowers</u> are inadequate as categories, as trees and shrubs also have flowers and as flowering herbs can be either wild or cultivated.

In Texas at least, the child's use of the term <u>flowers</u> resembles that of the adult layman, indicating that the child has grasped the meaning for the term as it is used by the adult.

The elementary textbook used <u>flowers</u> as a category occasionally, without explanation. Most visual examples were of herbaceous plants. The term <u>wildflower</u> was used in the text but not defined or illustrated.

<u>Herbs</u>, a term used in the textbook, grade 3, may be a more accurate label for the category but it was not used by any of the informants except in one culinary reference. Although botanists use the term <u>herb</u> in reference to any herbaceous plant, for the layman the term has culinary and medicinal connotations and is not typically used in reference to herbaceous plants in general.

The textbook defined <u>herbs</u> as being small plants with soft, non-woody stems (not always true). The text stated that grasses, flowers, and weeds are kinds of herbs. These statements perpetuate the myths that <u>flowers</u> include only herbaceous plants and that <u>weeds</u> are defined by structure.

<u>Grass</u>

      <u>Taxonomic classification</u>.

The informants used <u>grass</u> as a category generally at level 1, at the same taxonomic level as <u>trees</u>, <u>flowers</u>, et cetera. It seemed to function as a major plant category and probably could be considered a life form. On the other hand, at least four informants (3,4,7,8) considered <u>grass</u> a subset of the herbaceous category <u>plants</u>, and most of the members were named with secondary lexemes (<u>spear grass</u>, <u>monkey grass</u>). Thus in some ways, the informants treated the category like

a generic at level 2 (refer to Figures 4-14). If the category plant is viewed as a pseudo-unique beginner at level 0 (see discussion under plants above), then grass will be placed at level 1 in most cases. Even then, the taxonomic status of the category is problematic. Brown (1984) found grass to be a major category in most languages studied. He also found that members were named with secondary lexemes. Nonetheless, he felt that the category acted as a life form rather than a generic.

Five informants extended the category to include non-grass herbs that grow in the grass. The grass category may have served as a residual category, a catch-all for otherwise unclassified specimens (refer to section 2, "Children's Plant Classification Schemes" for further discussion of residual categories).

Informant 8 elevated grass to an intermediate level above flowers, weeds, and herbs, all herbaceous categories. For her grass seemed to be a large residual category as she showed no interest in differentiating the specimens further. For her grass was also a subset of plants, another vaguely defined herbaceous category. This classification was interesting in view of the elementary text classification, grade three, in which the text stated that grasses, flowers, and most weeds are examples of herbs. Was the informant simply regurgitating, in reverse order, misleading information she had read in a text three years ago?

Salience of the category.

Though all informants used grass as a category, only two used it as a primary category in the sorting task. Most informants used the category sparingly, probably because few examples of true grass were viewed. Only three informants used the grass category as often as the plants category, and only informant 4 used grass more than a dozen times (overgeneralized). As a category grass appeared to be less salient than trees and flowers, though the low number of grass species viewed could explain any differences in use.

C.H. Brown (1984) has speculated that grass is highly salient and is encoded early in the development of life forms in many languages (see Figure 2).

Basic level of abstraction for naming grasses.

Roughly 33% of grasses were named with primary or secondary lexemes at level 2 (if one assumes that grass always occurred at level 1). Some informants invented names or attempted to differentiate "regular grass" from atypical forms. For seven informants level 2 (generics or specifics) may have been salient in naming grasses.

Criteria for category membership.

Category selections indicated that the prototypical grass was mowed turf grass, a low-growing herb with no obvious flowers and narrow leaves. The category was monothetic for most informants. Greenness (lacking colorful flowers or brown wood) and herbaceous habit seemed to

be the critical criteria shared by virtually all specimens. If the specimen lacked the critical criteria, it would be thrown into another category. Leaf shape, although important, was not a critical criterion for five informants. Numerous low growing non-grasses were included in their categories.

Informants varied widely in category membership. Only two (informants 3 and 9) seemed to have a consistent botanical concept of grass, rarely including any non-grasses (and then only non-flowering herbs with grasslike leaves) and including most of the true grasses. For these informants the category may have been polythetic, with category membership determined by degree of fit with a family of criteria that included leaf shape, lack of typical flowers, and presence of the seeds typical for true grasses.

Informants 2 and 6 had a restricted usage, including only mowed turf (no tall grasses or grass in seed) and a very few non-flowering herbs with grasslike leaves (such as monkey grass). Their categories were predictable but unstable. Take away the lawn mower and grasses become weeds.

All other informants overgeneralized, resulting in unstable and unpredictable categories that were not botanically accurate. Though the prototype was a true grass, any number of low-growing herbs, such as clover and chickweed, may be included, when they were not flowering. Although specimens were consistent with the critical criteria, sorting was not exhaustive. A number of non-flowering herbs were always placed in other categories. For these five informants, the category may have served as a residual, a catch-all for low-growing unnamed herbs in the lawn that lacked showy flowers. When flowers appeared, the specimens were likely to be re-classified as flowers.

Overlapping categories.

When overgeneralized, the grass category was indistinguishable from and overlapped extensively with the other herbaceous categories, weeds, leaves, and plants. Choices of what specimens were placed in what herbaceous category seemed arbitrary and unpredictable. Grasses tended to be smaller than other herbs, however. Grasses often were included as a subset of the herbaceous category plants.

Of those who overgeneralized, only informant 7 did not overdiscriminate grass. Most informants placed any true grasses that did not closely match the prototype in any of several alternative categories, bushes, plants, weeds, and even flowers. True grass in seed was often the prototypical weed. A few informants were aware of overlap between grass and other categories, but at least two did not recognize that their weeds were actually grasses.

Adult meanings.

Grass is a botanical term referring to a plant family. True grasses have round, jointed stems. The leaves, usually narrow, sheathe the stems. Grass flowers are reduced to scaly bracts.

The selections made by seven informants demonstrated that they did not grasp the meaning of grass as it is used by a botanist. Only two informants made consistently accurate selections of true

grasses. Few true grasses were viewed so it was not possible to determine the extent of their abilities to recognize grasses in various forms. I would like to see how these informants would classify non-herbaceous grasses such as bamboo.

It is unlikely these children have ever been taught how to differentiate true grasses from other herbs. The textbook used the term grass but rarely gave visual examples and never defined the characteristics of grass. In grade three, grass was presented as an example of a type of herb. And then bamboo (which is not herbaceous) was given as the only named example of grass.

A term like grass has been found in most languages studied by ethnobotanists (C.H. Brown, 1984). C.H. Brown stated that the category typically includes small non-flowering herbs with narrow leaves (herbs that look like or are true grasses), but occasionally broadleaf herbs are included as well. Brown also found that some adults treat grass as a subset of the other major herbaceous category, grerb.

Although their selections were often not botanically accurate, the children in this study seemed to use the category in a manner very similar to adult laymen in various cultures. It may be that English speaking adults also tend to overgeneralize the category.

Vines/Ivy

Taxonomic classification.

The informants sometimes used the term ivy as a subset of vines but generally the terms were used interchangeably. The informants generally used vines at level 1, the same taxonomic level as flowers, trees, et cetera. At least three informants placed vines as a subset of the herbaceous category plants. If plants is viewed as a pseudo-unique beginner (see discussion under plants above) then vines always occurs at level 1. Vines probably qualifies as a life form (refer to Figures 4-14 and the discussion on life forms in section 2, "Children's Plant Classification Schemes").

Salience of the category.

Few specimens were called vines, partly because vines were not as common in central Texas as trees, shrubs, and herbs. Informant 2 selected 20 specimens. No one else had more than ten. Though the category was salient for all informants, no one used vines as a primary category in the sorting task. The category was probably less salient than trees, flowers, and possibly bushes. Vines with flowers were usually placed with flowers and woody vines were sometimes placed with trees or bushes. Trees were never called vines and flowering herbs were very rarely classified as vines. Some shrubs with elongated arching branches were called both bushes and vines.

The fact that numerous vines were placed in other categories did not necessarily mean that the informants did not recognize the specimens as vines. It may simply have meant that other categories were more salient. For example, after informant 3 completed the sorting task, I asked

him if there were any vines in any of the groups. He then accurately picked out the vines.

C.H. Brown (1984) found that <u>vines</u> is used as a category in many languages. He speculated that the category is encoded late in the development of most languages, after <u>tree</u> and <u>grerb</u>. Thus for adults in other cultures the category seemed to be low in salience.

<u>Basic level of abstraction for naming vines</u>.

About 33% of the <u>vines</u> were named at level 2. Most names were primary lexemes (generics) although made-up names typically were secondary lexemes (<u>thorn vine</u>, <u>berry vine</u>). Because so few specimens were placed with the <u>vines</u> it was difficult to determine whether the generic level was salient for naming <u>vines</u>. The tendency to use made-up names indicated a desire to name the specimens at a level less abstract than the life form.

<u>Criteria for category membership</u>.

The category was monothetic and for most informants stem form (elongated, slender, flexible stems) was the single critical criterion. Verbal statements indicated that these informants were aware that a variety of types of plants could be vines including vines on the ground, free standing shrubs with vining branches, and climbing vines with woody stems.

For several informants herbaceous habit (green stems) was also a critical criterion for selection of <u>vines</u>. Four informants did not include woody vines (grape vines and wisteria were sometimes called <u>trees</u>), although the bushy form of honeysuckle was typically viewed as both a vine and a bush.

Though monothetic the criteria were structural, not subjective, and remarkably stable. Although vines in nature vary considerably from herbaceous to woody, the typical stem form tends to be consistent.

Informants gave little verbal information about how to recognize <u>vines</u>. Based on the few verbal statements and specimens selected, it seemed that if informants did use a prototype, the prototypical vine was a climbing, herbaceous (or green stemmed) plant with long, slender, flexible stems.

<u>Overlapping categories</u>.

The informants did not sort the category exhaustively. One vine with large showy flowers, for example, was typically placed with the <u>flowers</u>, and four informants omitted the woody vines from the <u>vines</u> category. Thus informants overdiscriminated the category. Although most specimens were consistent with the critical criteria, only informants 6 and 7 included almost all vines (woody and non-woody) in the category.

Few informants overgeneralized the category. Only three informants included any specimens that

did not match the criterion of long, slender flexible stems. The inconsistent specimens included four low-growing herbs with stems that trail somewhat, one mistletoe in a tree, and one clump of leaves on the side of a tree trunk.

Adult meanings.

Vines is a folk category and is not part of the scientific classification scheme but botanists commonly use the category descriptively. The dictionary definition of vine is "any plant having a flexible stem supported by climbing, twining, or creeping along a surface."

A vines category has been found in most languages studied by ethnobotanists. Adults use the folk term in reference to plants with elongated stems that creep, twine, or climb (C.H. Brown, 1984, p. 14).

For at least six children category selections demonstrated that they grasped the meaning of the term vines as defined in the dictionary. Adult laymen and botanists could be expected to use the term in much the same manner as the children. One botanist might prefer to call yellow jasmine a shrub because it is free standing, but another botanist might call it a vine. In nature, plants with vining stems appear in a variety of different forms, sometimes forming bushy shrubs or low, ground hugging herbs. As used by adult laymen and botanists the category is monothetic, relying on stem form alone.

Although the children sometimes omitted woody vines, overdiscrimination of vines may have been an artifact of the low salience of the category. Not enough data was obtained to determine whether all the children recognized woody vines as vines.

In grade three, the textbook stated that vines are one of the four main groups of seed plants. Vines were described as having soft stems (perpetuating the myth that vines are never woody) and they cannot stand by themselves (not always true). Visual examples included climbing and crawling vines. The textbook seemed to have a restricted usage, relying on an herbaceous prototype, as did several of the students.

When presenting the scientific classification scheme in later grades, the text did not show the relationship between the folk classification scheme that included vines and the scientific classification that did not.

Cactus

Taxonomic classification.

The informants generally used cactus at level 1, on the same taxonomic level as trees and flowers. Due to extreme overlap with other categories, cactus could also occur as a subset of trees, bushes, plants, and flowers (refer to Figures 4-14). Informant 4 invented an intermediate category, prickly stuff, that included cactus, yuccas, and various other thorny plants.

Seven informants had one or no named members. Using Berlin's linguistic guidelines alone the category might seem to be a generic (Berlin, 1976). Because some informants' seemed to want to differentiate between specimens, I speculated that cactus could be a life form category. Three informants may have used cactus as a residual, a catch-all for otherwise unclassified thorny plants. Refer to the discussion on life forms in section 2, "Children's Plant Classification Schemes" for more information on ranking of the category.

Salience of the category.

The category was salient for at least seven informants. All informants used the category. Four informants (1,5,6,9) used cactus as a primary category in the sorting task. Four informants (1,5,6,7) used the category 10 to 24 times, all overgeneralizing considerably. Informants 2 and 8 classified fewer than five specimens as cactus. For them the category may not be very meaningful.

As a category cactus seemed to be less salient than trees and flowers. Informants typically placed some flowering cacti with flowers, and cacti with trunks were often classified as trees or bushes, but it was rare for a thorny woody plant to be called cactus.

Basic level of abstraction for naming cactus.

Students generally lacked names for cacti at level 2 (or level 3 if cactus was at level 2). Students relied on the life form label in reference to nearly all members. Several individuals attempted to differentiate between the various forms of cacti, indicating an ability to differentiate cognitively even though lacking linguistic differentiation. Level 2 (generic) names may have been preferred but were not linguistically salient for naming cactus.

Criteria for category membership.

For at least five informants the category was monothetic, with spines as the critical criterion. Almost all specimens chosen were consistent with the criterion, although category selection was not botanically accurate. The presence of a green stem probably was an important secondary criterion. Stem color may have prevented the inclusion of thorny trees in the category.

Category membership was generally predictable. The presence of thorns was a stable and usually a non-subjective criterion, though some non-thorny specimens such as dwarf palmetto (seen only in photographs) and some herbs were considered spiny by several individuals.

The informants did not provide enough statements to define the prototype cactus, if there was one. Two factors indicated that the informants did have a prototype in mind and that it was a true cactus. The informants consistently selected true cacti as members (although non-cacti were also included). In the sorting task two informants were asked to designate the specimens "most like a cactus." Both selected several true cacti, with only one non-cactus included.

Two species of cacti were shown in the textbooks, saguaro and prickly pear. Prickly pear cactus is the most common cactus in central Texas. Either of these may have exemplified the prototype for these children.

The informants did not vary considerably in their selections of <u>cacti</u>. Informants 3 and 4 included most of the true cacti and only one non-cactus, the Joshua tree yucca (which strongly resembles some true cacti), to their categories. Informant 9 overdiscriminated the category but did not include any non-cacti. These three individuals may have used resemblance to a polythetic prototype (distinguished by multiple features) for their selections. Their categories would very nearly be acceptable to a botanist.

Three informants (1,6, and 7) properly classified all the true cacti. These three also overgeneralized the category, however. They included various non-cacti, such as yuccas, agaves, and thistles. Although these three individuals seemed to have a sound concept of the variety of forms in which true cacti can be found, their categories would not be acceptable to a botanist. The children in Dougherty's study (1979) overgeneralized cacti in a similar manner (p. 309).

For the three who overgeneralized, category selection was ultimately monothetic relying on presence of spines alone. For some specimens, however, these informants may have had a polythetic prototype in mind. For informant 6 <u>cactus</u> seemed to be polysemantic. On the one hand, she grossly overgeneralized, including just about anything with spines (indicating a monothetic category, possibly a residual). On the other hand, she sorted the cacti into "most" and "least like a cactus." All members of the "most" group were true cacti and the "least" and "sort of" specimens were non-cacti (indicating a category based on resemblance to a polythetic prototype). She also described differences between types of <u>cactus</u> in the field.

      <u>Overlapping categories.</u>

The informants placed different forms of cacti in different categories, <u>tree</u>, <u>bush</u>, <u>flowers</u>, and <u>plants</u>. In general the informants were aware that some cacti fit more than one category. Five informants included at least one treelike cactus with the <u>trees</u> or <u>bushes</u>, and eight informants included at least one flowering cactus with the <u>flowers</u>. The overlap was inevitable as the informants were attempting to combine a scientific category, based on multiple criteria, with a monothetic folk category.

As with <u>vines</u>, overdiscrimination of the <u>cactus</u> category may have been the result of the low salience of the category. Some true cacti were placed in the more salient categories (<u>flowers</u>, <u>trees</u>) and I did not systematically question the children to determine whether they recognized that these were also cacti. I did ask informant 3 to pick out the cacti after his initial sort. He selected four of the six true cacti and only one non-cactus.

      <u>Adult meanings</u>.

<u>Cactus</u> is a scientific plant family name. The plural of <u>cactus</u> is <u>cacti</u>, a term that none of the

informants used. True cacti do not have leaves (with the exception of a few species that bear succulent leaves temporarily). Cacti are extremely variable in form. Some members have treelike forms, some resemble bushes, and some are low growing. Some can even be vines. Not all species bear spines, but they usually do have green stems. More than 70 species of cacti grow in Texas.

Cacti were not mentioned in C.H. Brown's study (1984). As cacti are native to the New World, the category would not be found in most languages. I have heard many adult laymen in Texas use cactus in reference to various non-cacti and true cacti. The adult layman's usage was reflected in the children's responses in two ways: most of the children recognized true cacti in a wide variety of forms; most children overgeneralized the category to include a variety of thorn-bearing plants (particularly yuccas and agaves) that are not true cacti. The selections of four informants would have been acceptable to the adult layman if not to the botanist.

Five informants (all the girls) included various prickly herbs in the category, probably overgeneralizing beyond what would be acceptable to the adult layman. I do not know of any studies of the adult layman's concept of cactus. It may be that some adults also include prickly herbs in their category.

Although most informants did not have scientifically accurate categories, the consistent selection of true cacti indicated that all informants had at least a partial grasp of the meaning of cactus as it would be understood by a botanist.

The elementary textbook analyzed illustrated cacti in every grade. Only two species were included in the text: saguaro (which does not grow in Texas) and prickly pear cactus (which does). The diversity of form in cacti was not represented in the text. The text included some information on adaptations to desert environments in grades four and six. Other than spines and a waxy stem, the text did not provide information on the distinguishing characteristics of cacti. In view of the limited textbook illustrations, the students' abilities to recognize a wide type of forms was remarkable.

Weeds

     Taxonomic classification.

Five informants seemed to use weeds as a major plant category, fitting into the plant hierarchy at level 1, the same taxonomic level as trees and flowers. Although the category had few named members, it may have qualified as a life form for these individuals (refer to Figures 4-14 and the discussion on life forms in section 2, "Children's Plant Classification Schemes").

For four informants (3,4,7, and 9) weeds may not fit into a hierarchical taxonomy. These four seemed to use weeds strictly as a residual, a dumping ground for otherwise unclassified specimens. These informants had very inconsistent category selections. Three of the informants who seemed to use weeds as a life form also may have used it as a residual part of the time.

<u>Salience of the category.</u>

Though all informants used the category, only three (1,2,6) used <u>weeds</u> as a primary category in the sorting task. Only four informants (1,2,5,6) classified 15 or more specimens as <u>weeds</u>. The five other informants used the category for fewer than eight specimens. The inconsistent selections and few numbers of specimens indicated that the category was not as salient as <u>trees</u> and <u>flowers</u>. For at least four informants (3,4,7,9) the category probably was lower in salience than the other herbaceous categories.

<u>Basic level of abstraction for naming weeds</u>.

Of all the categories, <u>weeds</u> was the one for which the informants had the least preference for using a generic label. No one used more than five generic names for weeds. Level 2 (generic) names were not linguistically salient for naming <u>weeds</u> and probably were not psychologically salient either.

<u>Criteria for category membership</u>.

<u>Weeds</u> was a troublesome category for these informants as it is for adults as well. I suspected that problems with the category came from the children's attempts to place structural criteria on a non-structural category. As used by adults <u>weeds</u> is a subjective category. It does not fit into a taxonomic scheme based on morphology as do <u>trees</u> and <u>bushes</u>.

While some informants seemed to know that a weed can come in various forms, several (informants 1,6,7,8) insisted that a weed has a specific structural form. Most informants seemed to have a non-flowering, wild, herbaceous prototype in mind when classifying <u>weeds</u>. Almost all selected specimens were herbaceous. For some individuals grass in seed was the prototypical weed, for others it was clover.

Only informant 7 had a woody prototype, the "weed tree," hackberry. Although he selected a variety of types of herbaceous plants as weeds, he clung to the notion that <u>weed</u> referred only to that one species of tree.

The informants varied widely in their stated criteria. For some appearance is important: if it's pretty, it's a <u>flower</u>; if it's ugly, it's a <u>weed</u>. For informants 2 and 6, a showy wild <u>flower</u> minus the flower became a <u>weed</u>. Only informants 2 and 9 seemed to use the common adult criterion, "grows where it's not wanted." For informant 5, any herb that grows wild, flowering or not, pretty or not, could be a weed.

Whatever the criteria used, selection seemed to be monothetic and was arbitrary and unpredictable. Sorting on a structural basis (such as for non-flowering herbs) was never exhaustive. Along with the other non-flowering herb categories <u>weeds</u> often served as a residual, a dumping place for plants that did not fit more salient categories. As a residual the category

included a wide variety of types of plants - herbs, vines, ferns, grasses, and woody plants.

       <u>Overlapping categories</u>.

<u>Weeds</u> overlapped into virtually all other major categories, though mainly the herbaceous categories. There was no obvious structural difference between the members of the <u>weeds</u>, <u>plants</u>, <u>grass</u>, <u>flowers</u>, and <u>leaves</u> categories. At least six informants were aware that they classified some <u>weeds</u> in other categories as well. Other informants did not seem to be aware of the overlap of <u>weeds</u> with other categories.

       <u>Adult meanings</u>.

<u>Weed</u> is not a botanical category. It is a folk category based not on structural but subjective criteria. The dictionary defines <u>weed</u> as, "A plant considered undesirable, unattractive, or troublesome; especially, one growing where it is not wanted in cultivated ground." The term is relevant mainly for farmers and ranchers who wage a constant battle with wild grown plants that displace agriculturally valuable species. That which is a <u>weed</u> to a farmer may be considered a beautiful <u>wildflower</u> by someone else.

C.H. Brown (1984) did not discuss <u>weeds</u> in his ethnobiological study. It is likely that the adult layman in central Texas uses the term <u>weeds</u> in as many diverse ways as do the children in this study. The typical layman probably lacks knowledge of the species that cause problems in agricultural settings. For the non-agricultural layman the category may be mainly residual. I have noted that adult laymen in Texas tend to call virtually any unnamed non-showy herbaceous plant a <u>weed</u>. Although the criteria may be subjective, adults may rely on an herbaceous prototype. Various trees, shrubs, vines, and herbs are considered <u>weeds</u> by farmers and ranchers but I have noted that, like these children, other adult laymen tend to restrict use of the term to herbaceous plants.

The elementary textbooks analyzed used the term <u>weed</u> only in a third grade reference. The text did not indicate that <u>weed</u> is a subjective category. No definition of <u>weed</u> was given. Rather than pointing out that the category does not fit into a taxonomy based on morphology, the text stated that most weeds are herbs. Goldenrod was given as an example. The text promoted the misconception that weeds are classified by structure.

<u>Leaves</u>

       <u>Taxonomic classification and salience of the category</u>.

<u>Leaves</u> emerged as a category for informants 6 and 9. They used the term as a name for a variety of types of plants. For informant 6 the category was probably strictly a residual and not salient as a life form. She used it for only three specimens.

Informant 9 used the category 15 times, more frequently than any of his other non-flowering herb categories. He used leaves as a primary category in the sorting task. The category may have more salience than his other non-flowering herb categories, except grass. Five of his specimens were named, several with made-up secondary lexemes (thorn leaves, three-pointed leaves). Selection of members was unpredictable and the category probably served as a residual, a catch-all for otherwise unclassified specimens.

Although his selections may have been strictly residual, the informant may have thought that leaves was a true plant category, on the same taxonomic level as trees and flowers. At one point, he said, "I know three-leaf clover is leaves because it's got the word leaf in it." The informant did not include leaves when asked to list all the categories of plants, however.

Informants 2 and 7 referred to several photographs as leaves, but for them the term was probably just a descriptor for unnamed objects (such as lichens, ferns, mistletoe, and Spanish moss) rather than a category. These informants may have been merely saying, "This thing looks like just leaves."

Basic level of abstraction for naming leaves.

Although for residual categories, the generic level is not expected to be salient, informant 5 actually named five leaves. This was another indication that the category was more than just a residual in the mind of the informant.

Criteria for category membership.

Informant 6 used leaves in reference to three low-growing green herbs, two without flowers and one with an inconspicuous flower. Perhaps leaves served as a means of distinguishing these herbs from the surrounding turf grass. For her the category was virtually indistinguishable from weeds and plants except that leaves were possibly considered to be smaller in size.

For informant 9 no obvious prototype or criteria emerged for classifying leaves. Some plants were included simply because they had "leaves" in the name. This individual used leaves for a wide range of specimens such as poison ivy, live oak seedlings, a leafy grape vine, English ivy, maidenhair fern, various non-flowering herbs, and water lily. The only thing these specimens had in common is that they were predominantly leafy.

Adult meanings.

Leaves, of course, is not a botanical category but is an anatomical part of a plant. The use of leaves as a plant category would be unacceptable to a botanist. I have assumed that the category would not be acceptable to adult laymen. The common use of the word "leaves" in names of plants (e.g., three-leaf clover) may have caused these children to assume that leaves is a true category.

Dougherty (1979) also found that young children used leaves as a plant category in California. She assumed that such usage would disappear with age. As it has not yet disappeared in at least two

12 year old children, this researcher cannot assume that <u>leaves</u> has disappeared as a category in the adult vernacular.

<u>Fruits and Vegetables</u>

      <u>Taxonomic classification</u>.

Five informants seemed to use <u>fruits</u> and <u>vegetables</u> at level 1 in the same taxonomic scheme as <u>trees</u> and <u>flowers</u>. Informants classified <u>trees</u> on the basis of structure and <u>fruits</u> and <u>vegetables</u> on the basis of edibility. The informants did not seem to be aware of any contradiction in placing both in the same classification scheme.

As the categories included numerous members named with primary lexemes (generics), <u>fruits</u> and <u>vegetables</u> qualified as life forms.

      <u>Salience of the categories</u>.

In the listing task, the informants remembered more names for <u>fruits</u> and <u>vegetables</u> than for any other folk categories except <u>trees</u> and <u>flowers</u>. These four categories were the most salient categories for virtually all informants.

      <u>Basic level of abstraction for naming fruits and vegetables</u>.

The informants supplied numerous generic names for <u>fruits</u> and <u>vegetables</u>. They rarely, if ever, used the life form label for naming. The generic level clearly was salient for naming <u>fruits</u> and <u>vegetables</u>.

      <u>Criteria for category membership</u>.

Most informants stated that <u>fruits</u> and <u>vegetables</u> are kinds of plants. Sweetness tended to be used as a monothetic criterion for distinguishing <u>fruits</u> from <u>vegetables</u>. Informant 8 added several sweet foods that were not fruits to her list (e.g., sugar cane and honey).

Only informant 9 stated that <u>fruit</u> has seeds, a botanically accurate criterion. He erroneously stated that <u>fruit</u> grows on trees but <u>vegetables</u> grow in the ground. Although not accurate for all fruits and vegetables quite a few do fit that description.

Informant 4 revealed misconceptions about plant foods versus animal-derived foods. He thought that eggs were plants. He also included animals under a miscellaneous category when asked to list all the categories of plants.

Though several members were aware that tomatoes can be both a <u>fruit</u> and a <u>vegetable</u> (because they're not sweet), they seemed to believe that <u>fruits</u> and <u>vegetables</u> are supposed to be mutually

exclusive categories.

Adult meanings.

An adult would agree with most of the informants selections of fruits and vegetables. The dictionary defines fruit as "the ripened ovary of a seed bearing plant, containing the seeds." Vegetable is "a plant cultivated for an edible part." From the dictionary definition, it is clear that fruit is based on structure but vegetable is based on edibility. Thus a fruit can be a vegetable and vice versa.

Fruit, as defined above, is a botanical term. Vegetable, however, is not; it is a culinary folk term. The second dictionary definition for fruit is "An edible, usually sweet and fleshy form of such a structure." This second definition is also a culinary folk term and coincides with the child's definition. Thus it becomes clear that children use the term fruit in a culinary sense. The children's selections for fruit were consistent with the culinary definition even when they selected sweet edible objects that did not qualify as fruits structurally.

The elementary textbooks analyzed did not explain the differences between the folk and botanical definitions for fruit. Nor did the text explain how some fruits can be vegetables. The text did not explain that classification of edible plants is a separate operation from the classification of plants based on structure.

In grade three the text provided some information on vegetables, stating that they contain starch and sugar. The elementary textbooks stated that flowers produce fruits and that fruits contain seeds (grades 2, 3). Several of the children in this study were unaware of the relationship between flowers, fruits, and seeds (refer to discussion of concrete concepts in the textbook analysis for more details). With the exception of some written text and illustrations in grade three, the textbooks tended to promote the culinary definition of fruit by presenting examples of fruits that were fleshy, sweet, and edible.

Categories for Plants: Summary of Level 2 Assertions

Children's categories versus adults' categories

The children in this study commonly used the following major plant categories: plants, trees, bushes, flowers, vines, grass, cactus, weeds, fruits, and vegetables. Two informants used leaves as a category. Other categories that were used occasionally (but not analyzed) included: moss, mold, ferns, mushrooms, and berries.

With exceptions noted earlier, many of the informants' selections for the categories trees, bushes, flowers, vines, grass, cactus, weeds, fruits, and vegetables would be acceptable to an adult layman. With the exception of leaves, all the students' names for plant categories would be recognized by the adult layman. Thus it seems likely that the children's meanings for major plant

categories were similar to those of adult laymen.

The labels for all categories except flowers and leaves would be acceptable to a botanist. The botanist would be more inclined to refer to shrubs rather than bushes. In no category did all informants have botanically accurate domains. Thus, for no category could it be said that all informants shared meanings with botanists. Several informants (two to six informants in each category) had botanically acceptable domains for the categories tree, bush, grass, vines, cactus, fruits, and vegetables.

Only one informant seemed to use plants consistently in a manner that would be acceptable to a botanist. For most informants plants was polysemantic (had multiple meanings). Although most recognized that trees can be plants, the informants rarely used plants as a unique beginner. The category usually was used in reference to herbaceous, non-flowering plants or as a residual category, a dumping ground for otherwise unclassified specimens.

Even for those informants who knew that trees are supposed to be types of plants, there was a strong tendency to believe that trees are not "real plants." At least seven informants seemed to separate all plants into two broad categories. These divisions were named trees versus plants or were implied. Woodiness, size, and color may have been the criteria used to differentiate these two divisions. Trees and bushes were the only categories with consistently brown-stemmed (woody) members (although some non-woody specimens were occasionally placed in these groups). Most members of plants, grass, weeds, leaves, and flowers were green-stemmed (herbaceous) and smaller than trees and bushes. Vines were generally non-woody although some informants included woody specimens as well. Members of cactus had green stems but were often as large as trees and bushes, and members overlapped into both woody and non-woody categories. Notably, the scientific plural of cactus is cacti, but no informants used the plural form.

Botanists sometimes use a binary division of flowering plants, with the divisions labeled woody versus herbaceous. The informants did not use the label herb except in one culinary reference.

The children in this study used their categories in a manner very similar to that of Dougherty's children (1979). Her oldest informants used the following major plant categories: plants, trees, bushes, flowers, vines, grass, cactus, leaves, ferns, mushrooms. Dougherty also noted a polysemous use of the category plants.

Dougherty also found that her children tended to place plants into binary sets (trees versus plants). C.H. Brown (1984, p. 100) speculated that binary contrast (e.g., large versus small) is a common method of encoding plant and animal life forms in languages.

Children's categories versus textbook categories

The elementary textbooks used plants in a botanically accurate manner. In grade three, the text stated that plants are divided into four groups, based on stems: trees, shrubs, herbs, and vines. Notably, this is not a scientific classification scheme. In grade four, the text introduced a scientific

classification scheme, based on reproductive characters. The text did not explain how the folk categories introduced in grade three fit into the botanical classification scheme introduced in grade four.

The informants' verbal definitions for the folk categories <u>tree</u>, <u>flowers</u>, <u>vines</u>, and <u>weeds</u> were generally compatible with usage in the elementary text. The informants' <u>bush</u> category was similar to the <u>shrub</u> category of the text. The text did not define <u>weeds</u> or <u>flowers</u> as categories although it used them as such. The text did not explain the differences between botanical and culinary meanings for <u>herb</u>.

With the exception of "conifers," the informants' did not use the scientific categories (e.g., monocot, dicot) introduced in the elementary textbooks. Although a botanist would consider the categories <u>cactus</u> and <u>grass</u> as scientific plant families, most informants used them as overgeneralized folk categories. The text did not indicate how these categories fit into a scientific classification scheme.

In some cases, the informants' selections indicated a better understanding of a category than did the text. The text used a restricted definition for <u>tree</u>, <u>shrub</u>, and <u>vine</u> that did not take into account the diverse forms in which these plants can appear.

<u>Criteria for classification</u>

Most of the informants' major plant categories relied on structural, non-subjective attributes as the main criteria for selection of members. For <u>trees</u>, <u>bushes</u>, <u>vines</u>, and <u>cactus</u> the presence or absence of the criterial characteristics does not vary from season to season. <u>Vines</u> do not lose their long, slender stems as they get older. <u>Cactus</u> do not lose their spines. These categories were generally stable (membership would not change seasonally) and informants' selections were fairly predictable.

For the various herbaceous categories, the informants' structural criteria were virtually identical and differentiation between the herbaceous groups was dependent either on variable criteria, such as the presence or absence of flowers, or subjective criteria such as prettiness.

The combination of variable and subjective criteria made the herbaceous categories unstable, resulting in extreme overlap. When an herbaceous plant had a flower, it usually was placed in the <u>flowers</u>. When the flowers were absent, the species might be called a <u>plant</u>, <u>grass</u>, <u>weed</u>, or <u>leaf</u>. <u>Flowers</u> is an unstable category although fairly predictable. The alternative herbaceous categories were usually unstable and unpredictable. Selection was based on the absence (rather than the presence) of the critical criterion, flowers, and an arbitrary choice between four categories that tended to act as residuals (refer to discussion of residuals in section 2, "Children's Plant Classification Schemes"). As residuals, these categories served as dumping grounds for otherwise unnamed herbaceous plants lacking an obvious flower.

Despite the sometimes unstable criteria chosen by informants, there was remarkable agreement

between students on what criteria were important for each category. Most structural criteria used by the students, such as overall form, size, leaf type, trunk form, stem form, and herbaceous or woody habit (which for these children may have been indicated by color of stem), were criteria that botanists use in classifying plants.

Classification of <u>weeds</u> was based on subjective criteria as well as unstable structural criteria. For some informants, any plant was a <u>weed</u> if it grew where it was not wanted. For others a flowering herbaceous plant was a <u>flower</u> if it was pretty and a <u>weed</u> if it was not. <u>Grass</u> was a predictable category only for those few informants that relied on leaf shape as a criterion.

Dougherty (1979) found that children as young as three years old used structural criteria for classification of plants. She also noted a tendency to use unstable criteria (e.g., presence of flowers, fruit, or leaves). She assumed the children would be less likely to use unstable criteria as they got older. The results of this study have indicated that such tendencies remain in older children.

Classification and student performance

The nine informants varied considerably in how accurately and consistently they defined their categories. Table 2 shows the number of categories each child used that fit various performance criteria (e.g., the categories had stable criteria). The table indicates how many categories were polythetic, monothetic, or residual, how many would be acceptable to a botanist or an adult layman, and how many categories were overgeneralized or overdiscriminated. Seven informants used eight of the categories discussed above. Informants 6 and 9 used a ninth category, <u>leaves</u>.

The data revealed that the informants' categories that would be acceptable from the viewpoint of a botanist typically had the following characteristics: selected members were consistent and predictable in relation to a polythetic prototype; criteria for category selection must be stable, not varying with the seasons or other factors, and structural, not subjective. <u>Vines</u> was the only monothetic category acceptable to a botanist. It was also the only monothetic category with stable structural criteria.

A category was considered to be acceptable to an adult layman if the members selected were predictable based on a layman's typical usage (this was hypothetical as no laymen were tested. However, this researcher has extensive experience with adult uses of plant categories). Research with adults may demonstrate an even greater similarity with the children's categories than has been speculated here.

Informants 3 and 9 demonstrated the best overall performance. These students had the most number of categories acceptable to a botanist, the lowest number of overgeneralized categories, and the most number of stable, polythetic categories. Informant 3 had the fewest residual categories. Both had low national achievement test scores (refer to Table 1). Both were placed in below average classes in their school. A glance at the section "Names for plants" reminds us that these two gave some of the lowest numbers of correct generic names for plants but that both had

a strong preference for using generic labels.

Table 2: Number of Children's Plant Categories that Fit Various Performance Criteria

Informant Identification Number									
Indicators of Performance[a]	**1**	**2**	**3**	**4**	**5**	**6[b]**	**7**	**8**	**9[b]**
Acceptable to a Botanist	0	0	3	1	2	2	3	1	3
Acceptable to a Layman	2	4	7	6	4	6	7	4	6
Stable	4	4	6	4	5	4	6	5	5
Overgeneralized	6	6	3	3	4	6	3	3	2
Overdiscriminated	5	7	7	8	7	3	4	6	7
Polythetic	2	1	5	2	2	3	2	1	3
Monothetic	6	5	2	5	5	4	5	5	3
Residual	4	3	2	4	4	4	3	5	4

[a]Number of categories
[b]Informant had nine categories

Informant 7 performed nearly as well. Informants 3 and 7 both preferred outdoor play. Informants 1,2,4,5,6, and 8 performed poorly to moderately well. These six had fewer categories acceptable to either a botanist or an adult layman, few polythetic categories, a large number of monothetic and residual categories, and a large number of overgeneralized and/or overdiscriminated categories.

Informant 4 revealed serious misconceptions concerning classification. In sorting the photographs, he sometimes classified plants on the basis of characteristics in the background (such as water and red sunsets). This informant had high achievement test scores. Thus it was apparent that achievement test scores were not a predictor of performance in plant classification. Achievement test scores and student performance in naming plants have been discussed in "Section 3: Names for Plants."

Categories for Plants: Level 3 Assertions

Prototype theory

This study provided evidence that the children used prototypes in plant classification. For most categories, the prototype was readily apparent. The verbal statements made by the informants evoked a mental image of a particular type of <u>tree</u> or <u>bush</u>, for example.

The strongest evidence of the use of prototypes was apparent in the polythetic categories of the informants. Informants also seemed to rely on prototypes for their monothetic categories.

Table 3 presents the researcher's inferences concerning what categories were used as monothetic or polythetic life forms and what categories were used as residuals. A polythetic category is distinguished by (rather than defined by) multiple features. A monothetic category depends on only one or a few critical (necessary and sufficient) criteria to define membership. A residual is a dumping ground for otherwise unclassified plant specimens.

Table 3: Number of Informants that use Nine Folk Botanical Categories as Polythetic, Monothetic, or Residual Categories

Type of Category		
Botanical Folk Category	**Polythetic Life Form**	**Monothetic Life Form**	**Residual**
Bushes	3+	3-6	6
Cactus	3	5-6	3
Flowers	0	9	0
Grass	2	6	5
Leaves	0	0	2
Plants	2	3	9
Trees	9	0	0
Vines	0	9	0
Weeds	0	4	7

Few categories were polythetic. As has been discussed in section 2, "Children's Plant Classification Schemes," the children used some categories as both monothetic life forms and residuals.

For five informants trees may have been the only polythetic category. For three or more informants bushes may have been polythetic. For at least two informants grass and cactus seemed to be polythetic categories. The polythetic categories had more consistent and predictable members than did the monothetic categories. The monothetic categories were more likely to be used as residuals. Eight informants had one or more categories that served strictly as residuals.

With the polythetic categories, a variety of sources of evidence pointed to the importance of prototypes. When asked to explain how to identify a tree, for example, the informants' statements evoked a mental image of a specific type of tree. Although tree selections were predictable the informants' verbal statements (exemplifying the prototype) did not match the wide range of plants the informant actually chose for the category.

In polythetic categories, specimens were selected by virtue of sharing any one or more of a family of characteristics. Typically no criterion was shared by all members, but each member shared one to several criteria with the prototype. Few specimens shared all of the criterial attributes of the

prototype. No single criterion was necessary and sufficient to category membership.

In the informants' polythetic categories, membership was based on degree of resemblance to the prototype. Specimens sharing several or all criteria of the prototype tended to be designated as "most like" the category. Specimens sharing only one or few criteria with the prototype tended to be designated as "least like" the category. A gradation of shared criteria was apparent. Thus the category included prototypes with extension (selected members either match the prototype or have gradually fewer attributes of the prototype, i.e., they extend out from the prototype).

With increasing distance from the attributes of the prototype, specimens shared more attributes with other categories. Specimens on the fringes of the category were often classified in more than one category. For example, a small tree with more than one trunk might sometimes be called a bush. A bush with long, flexible branches may sometimes be called a vine. With the overlapping categories tree/bush, the atypical members were at the fringes of the categories with an obvious gradation of shared characteristics from one category to the other. Refer to the section "overlapping categories" below for further information on gradations between categories.

In a polythetic category, what criteria are shared varies whereas with monothetic categories, the shared criteria is always the same. Thus, there is no apparent gradation of characteristics in a monothetic category. Membership is on an all-or-nothing basis.

Even when the category was monothetic, the informants' selections and statements provided evidence that the children usually had a prototype in mind. For example, although presence of flowers was the critical criterion for membership in flowers the informants' statements and selections both pointed to an herbaceous prototype. In the monothetic categories, apparently there was no gradation of membership. There was no extension out from the prototype. Either the specimen matched all the critical criteria of the prototype or it was not included as a member of the category.

In this study, generally only specimens that shared all the critical criteria were included in the monothetic categories. The common tendency to use several of the monothetic categories as residuals resulted in some unpredictable selections. For example, while most specimens selected as weeds were herbaceous, indicating a tendency to rely on an herbaceous prototype, a few woody plants might be included also.

The textbook and dictionary definitions for tree, shrub, and herb indicated a tendency to present the prototype as the definition. The definitions were too restricted and not encompassing the wide range of plants that can be included in each category.

Overlapping categories

The research by Rosch and Mervis (1975) and by Kempton (1981) has demonstrated that in addition to prototypes folk categories have a degree of boundary overlap. The current research revealed that the informants' life form categories did overlap with each other. All informants

placed different specimens of the same species in different life form categories from time to time, and all informants acknowledged that some specimens shared the attributes of more than one category. For example, several students commented that a "cedar" can be called either <u>tree</u> or <u>bush</u> and that a <u>cactus</u> can also be a <u>tree</u>, <u>plant</u>, or <u>flower</u>. Several informants pointed out that honeysuckle is like a <u>vine</u> and a <u>bush</u>.

In the sorting task, I asked the children what specimens were "most like, least like, or sort of like" a tree. These phrases (known as hedges) indicate whether or not the boundaries of a category are sharply defined. Each informant readily used at least two hedges for differentiating between members of a category. Five informants used all the hedges. The use of hedges provided additional evidence that the boundaries of the informants' categories were not sharply defined, rather the boundaries overlap. Kempton (1981) and others have referred to overlapping boundaries as fuzzy boundaries.

Though category selections and use of hedges demonstrated that all of the informants' categories had a degree of boundary overlap, some informants had a greater awareness of that overlap than others. For example, when asked to list all the categories of <u>plants</u> informant 6 spontaneously developed a list and discussed what categories overlapped with each other. That list, along with the informants' commentary, is given below.

....

Informant 6 plant categories: 1 - cactus; 2 - deciduous (tree); 3 - conifer (tree); 4 - flowers; 5 - water plants; 6 - fruit bearing trees; 7 - weeds (brush); 8 - vines; 9 - thorny (thorns).

Informant stated: "2 and 3 do not go together, they're just one or the other. 4 and 5 can go together. Fruit bearing plants can go with either 2 or 3, because a conifer or a deciduous can have fruit. Now weeds can definitely go together with thorns and flowers. Vines sometimes have little berries but I don't consider them fruit, well, they are kind of, but just tiny-weeny ones. 8 and 6 go together. 4 and 7 can go together. Flowers and weeds can go together. 1 and 8 cannot go together. I don't think a cactus can grow on a vine. Maybe it can but I've just never seen one. Fruit and cactus don't go together to me. They give water and everything, but I don't think there's any cactus that has fruit. And, you know, of course, 7 and 2 and 3 don't go together. There aren't any weeds growing off trees. And I would say...2 and 9 go together, because mesquite tree has those little thorny things."

....

On the other hand, informant 1 seemed to have little awareness of boundary overlap even though most of her categories were overgeneralized. When asked to pick out specimens "most like a tree," Informant 1 moved all specimens that she did not consider "most like a tree" out of the tree category completely. When asked which non-trees were "sort of like a tree," she picked out some of these same specimens plus all the bushes. Informant 9 was able to pick out specimens that he considered "most" and "least like a tree," but when asked to select the non-trees that were "sort

of like a tree," he said, "None."

With the monothetic categories, <u>flower</u>, <u>plant</u>, <u>grass</u>, <u>weed</u>, and <u>leaf</u>, overlap was so extensive as to make the categories virtually indistinguishable to the outsider. For example, a bluebonnet without a flower became a <u>plant</u>, not a <u>flower</u>. And <u>grass</u> in seed becomes a <u>weed</u>. Though some informants were aware that they had double classifications, some were not. For some informants, there was a tendency to insist that these categories were mutually exclusive. These five categories represented attempts to differentiate between various types of herbaceous plants but to the outsider the differences seemed subjective and arbitrary.

For most categories, particularly the monothetic categories, sorting was rarely exhaustive. Seven informants overdiscriminated most of their categories (for example, some informants do not include all cacti in "cactus"). Fewer categories were overgeneralized. <u>Bush</u>, <u>grass</u>, and <u>cactus</u> were all commonly overgeneralized. For example, informants often placed yuccas and other thorny non-cacti with <u>cactus</u>.

Overdiscrimination and overgeneralization are both inevitable artifacts of a folk classification system. The criteria for category selection overlap so extensively that the individual can never attain a well-sorted classification.

The notion that trees and shrubs, or shrubs and vines, for example, are mutually exclusive categories with no boundary overlap may be a common adult misconception. This belief is held by botanists as well as laymen. The researcher (Tull, 1989) had seven adults, including three college professors and three botanists, fill out a questionnaire on folk categories. The responses revealed that four did not think that their folk categories had overlapping boundaries. Of the four, two were botanists and two were college professors in other fields. The botanists' responses were particularly surprising. Technical botany manuals frequently describe a plant with an opening phrase such as, "shrub or small tree," or "herbaceous to somewhat woody perennial," or "shrubby climber." The technical manuals point out overlap between trees and shrubs, herbaceous and woody plants, and shrubs and vines, and yet some botanists seem to deny that such overlap exists.

In examining the elementary textbooks, it was apparent that the texts did not acknowledge any overlap between the folk categories introduced in grade three (<u>trees</u>, <u>shrubs</u>, <u>herbs</u>, <u>vines</u>). Textbook definitions tended to present the categories as if they were mutually exclusive. The text may therefore promote a misconception that folk plant categories have clearly defined boundaries.

Botanical categories based on reproductive characteristics do not overlap to the extent that do folk categories. The elementary textbooks did not introduce the botanical concepts of family, genus, and species. The children, therefore, had not been introduced to the scientific plant categories most closely aligned with their folk categories.

Differences Between Categories in Basic Level for Naming Plants

As explained in the Chapter IV section "Names for Plants" below, for most informants there was evidence of a preference for generic names overall, even when the life form was used more frequently. I examined each plant category for evidence of differences between categories in terms of the level of abstraction used for naming members. Although the informants had some individual differences, the evidence was strikingly similar from student to student. For some categories the generic level was linguistically salient and for others it was not.

The number of named generics included in each life form category varied considerably. In all types of interviews, the informants gave members of the categories trees and flowers generic names more frequently than any other categories. Members of these categories were also accompanied by descriptions more frequently. The generic level was linguistically salient and psychologically basic for naming trees and flowers.

At least five informants divided plants into subsets. Those subsets (such as "water plants") usually had named generic members. In an average of all informants, approximately 30% of all specimens called plants were named generically. Approximately 33 % of all grasses and vines were named. When used as true life forms, therefore, the generic level was used often enough to indicate that generic names were preferred.

For two to nine informants grass, plants, cactus, bushes, leaves, and/or weeds served as residual categories, dumping grounds for otherwise unclassified specimens (refer to Table 3). A residual usage indicated that the individual was not differentiating the members of the category below the life form level (e.g., for some informants a bush is "just a bush"). When used as residual categories, the life form level of abstraction was linguistically salient and probably preferred. Even when used as a life form, bush, cactus and weeds rarely were named at the generic level. The life form level was salient. The category grass, however, was commonly named at the generic level when used as a life form. Although only informant 9 used leaves as a primary category in the sorting task and he used the category as a residual, 33% of his selections were named at the generic level. For this informant, the generic level seemed salient.

Some informants differentiated between various types of bush and cactus even when lacking generic names. The generic level, however, was not linguistically salient in naming members of bush and cactus.

In summary, it seemed that plant categories differed in respect to the levels of abstraction that were salient for naming members. For residual categories, the life form typically was salient. For life form categories, the generic level typically was salient. There was no evidence that the intermediate levels (such as conifer or wildflower) were as salient as the generic level. Each intermediate category had some named generic members.

<u>Differential salience of categories</u>

In the listing task, for only four categories, <u>trees</u>, <u>flowers</u>, <u>fruits</u>, and <u>vegetables</u>, did the informants make a substantial list of generic names from memory. For other categories the informants gave no names or only two or three names. In the slide, sorting, and field interviews, the categories <u>trees</u> and <u>flowers</u> were used more frequently than other categories and more of their members were named at the generic level. Category membership was generally consistent and predictable. These four categories were linguistically highly salient for the children.

The categories <u>bush</u>, <u>cactus</u>, and <u>plants</u> also were linguistically salient. Seven informants used <u>plants</u> as a category in the first sort of the sorting task, all nine used <u>bush</u>, and four used <u>cactus</u>. These categories had fewer members than <u>trees</u> and <u>flowers</u>, however. The categories were less salient than <u>trees</u> and <u>flowers</u>. Member selection was frequently unpredictable. Informants typically placed some flowering cacti and shrubs in <u>flowers</u>, and cacti with trunks might appear in <u>trees</u> or <u>bushes</u>. But it was rare for a thorny woody plant to be called <u>cactus</u>. And while several multiple-trunked woody plants were usually placed with the <u>trees</u>, very rarely were single-trunked woody plants called <u>bushes</u>.

The categories <u>vines</u>, <u>weeds</u>, <u>grass</u>, and <u>leaves</u> had fewer members than most other categories. In the sorting task only two informants used <u>grass</u> in the first sort and no one used <u>vines</u>. As fewer examples of vines and grasses were viewed by the informants, these results were not surprising. Both categories seemed to be meaningful for the children although secondary in salience to <u>trees</u> and <u>flowers</u> and possibly <u>bushes</u>. Vines and grasslike herbs with flowers were usually called <u>flowers</u>, and woody vines were sometimes placed with <u>trees</u> or <u>bushes</u>. Some informants included these categories as subsets of other categories (such as <u>plants</u> or <u>flowers</u>).

<u>Leaves</u> was only used as a residual and membership was unpredictable, thus it was not a true life form category and it was not as salient as <u>trees</u> and <u>flowers</u>. As informant 9 used <u>leaves</u> more often than other non-flowering herbaceous groups the category seemed more meaningful for him than other herbaceous categories. For three informants, <u>weed</u> was used strictly as a residual. Even when used as a life form, membership was inconsistent. For only four informants was the category as salient as other non-flowering herbaceous categories.

In summary, the categories <u>trees</u>, <u>flowers</u>, <u>fruits</u> and <u>vegetables</u> were more linguistically salient than other categories and seemed to be more meaningful to children. What factors lead to differential salience? The data indicated that children remember best names for plants that have relevance to their daily lives - plants that produce food, lumber, or other products, and plants that produce attractive ornamentation (particularly trees and flowering herbs).

The category <u>flowers</u> was probably meaningful due to the attractive nature of the bright colors of flowering herbs. In Texas much publicity has been given to native "wildflowers." The large size of trees makes them more noticeable than other plants. And children use fruits and vegetables in daily life.

<u>Differential salience and residual classification</u>

I have speculated that for the categories based on structure (i.e., all categories except <u>fruits</u> and <u>vegetables</u>), <u>trees</u> and <u>flowers</u> were psychologically basic or primary in the minds of the children. When attempting to classify an unfamiliar plant, the child may have tried to match the specimen with the prototypes of these categories first. If the specimen did not match either category, it was likely to be relegated to a less salient category by default.

For example, if the informant had a clear mental concept of <u>trees</u> but was less sure about what qualified as a <u>bush</u>, he or she might feel safer calling an atypical woody plant a <u>bush</u>. Thus <u>bush</u> becomes a residual category with inconsistent members.

Differential salience may have been the main determining factor for what life form categories became residuals. The boundaries of the less salient categories were less well-defined and more fuzzy than those of the more salient categories. Thus an unknown specimen could be placed in the less salient categories without causing too much cognitive dissonance.

Five or more informants seemed to use <u>bush</u>, <u>grass</u>, and <u>plants</u> as both life forms and residuals (refer to Table 3). All informants seemed to use <u>cactus</u> as a life form but three informants may have used it as a residual as well. <u>Weeds</u> may have served strictly as a residual for three informants and as both a life form and a residual for the others. <u>Leaves</u> was strictly a residual. <u>Vines</u> was not used as a residual but was not considered highly salient, since it was never a primary category in the sorting task.

In Figure 3 (below) is presented this researcher's theory of the relative salience for the major plant categories. The model is speculative. Further research is needed to learn more about the implications of these findings.

C.H. Brown (1984) also found evidence of differential salience in plant categories. He considered <u>trees</u> to be the most highly salient category in virtually all cultures studied. The category occurs in virtually all languages and is used the most frequently. <u>Grerb</u> and <u>grass</u> are secondary in frequency of use, with <u>vines</u> and <u>bush</u> lowest in frequency of use. Brown did not examine the categories <u>flowers</u>, <u>fruits</u>, and <u>vegetables</u>. Refer to Figure 2 for C.H. Brown's model of the linguistic development of life form categories.

trees flowers	→	plants bushes cactus vines grass leaves	→	weeds leaves grass

Primary salience   Secondary salience   Tertiary salience
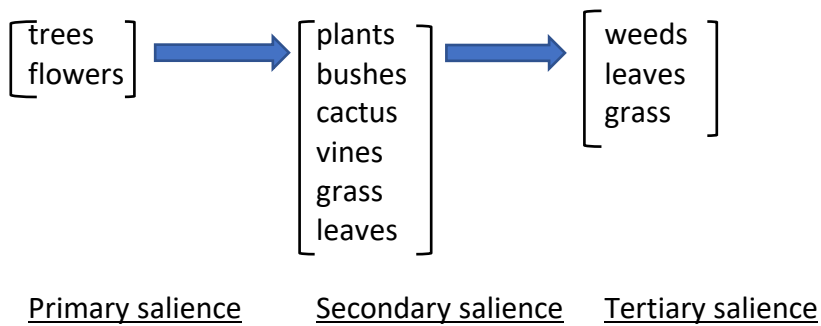
Figure 3. The researcher's hypothetical model of the relative salience of nine folk botanical categories

<u>Categories for Plants: Summary of Level 2 and 3 Assertions</u>

Although the students did not use scientific plant categories (e.g., monocot, dicot) all their major plant categories, with the exception of the category <u>leaves</u>, would be recognized by the adult layman and generally used in a similar manner. Although specimens selected differed idiosyncratically, the basic defining attributes of categories and the prototypes tended to be similar from child to child. Some folk categories (<u>flowers</u>, <u>leaves</u>) would not be acceptable categories from the point of view of the botanist. But botanists do use some folk categories (e.g., <u>tree</u>, <u>vine</u>) in describing plants.

The children's categories were based mainly on structural criteria (<u>weeds</u> and <u>leaves</u> being notable exceptions). When selection criteria were not based on seasonal changes, the categories were stable. For example, once a tree attains a mature state, trunk size changes little from year to year. The herbaceous categories tended to be unstable (relying on attributes that change seasonally, e.g., presence of flowers) and somewhat subjective and, therefore, unpredictable. The children tended to agree on what criteria was important for category membership. Many of the attributes that the child noted when describing specimens were the same attributes that a botanist would use.

Two types of life form categories were used: polythetic, with category membership depending on degree of resemblance to the prototype, and monothetic, with category membership dependent on the presence of a few critical (necessary and sufficient) criteria. Regardless of category type, category membership was generally based on a prototype. With polythetic categories a gradation of attributes from "most like" to "least like" the prototype was possible. With monothetic categories, membership was generally on an all or nothing basis, either the specimen shared all the critical criteria or it was not included. Category membership seemed to be based on a prototype most of the time, but inconsistent members indicted that most categories (all except <u>trees</u>, <u>flowers</u>, <u>vines</u>) were also used as residuals from time to time.

Students' categories were often overdiscriminated and/or overgeneralized in comparison with

what would be acceptable to a botanist. Boundaries of categories overlapped. Overlap was fairly predictable for the categories <u>tree</u> and <u>bush</u> but for the monothetic herbaceous categories, overlap was generally unpredictable and arbitrary.

Categories for plants seem to differ in respect to the levels of abstraction that were salient for naming members. Some categories seem to be more meaningful than others. Differential salience may be the main determining factor for which categories become residuals.

Section 2: Children's Plant Classification Schemes

Level 2 Assertions

Based on the domain analyses and componential analyses, the taxonomic analysis was used to evaluate the hierarchical relationships between the informants' folk categories. Berlin's hierarchy (Figure 1) provided the model for the informants' folk classification schemes (Berlin et al., 1974). The children's classifications schemes were used to examine what levels of abstraction were salient in naming plants (for discussion, refer to section 3, "Names for Plants").

Refer to Figures 4-14 for the models of each informants' classification scheme, as inferred by the researcher. In those models, the following abbreviations have been used: UB = unique beginner, LF = life form, I = intermediate, G = generic, S = specific, V = varietal.

Each of the children's folk categories overlapped to a greater or lesser extent with other categories in the hierarchy and several categories were polysemantic (had multiple meanings). Thus the categories were not stable in their hierarchical relationships to each other. The models have demonstrated the polysemantic usage of the category <u>plants</u> by showing the category at several levels of abstraction or by giving more than one model per student.

Only six informants knew that <u>plants</u> could be an all-encompassing term. For them, the models have shown <u>plants</u> at the unique beginner level with <u>trees</u> included as a subset. All informants except number 9 also used <u>plants</u> at lower levels of abstraction most of the time. Six students seemed to use <u>plants</u> at an elevated intermediate level possibly in binary opposition to <u>trees</u>.

Six informants used <u>plants</u> at the life form level. Eight informants also used <u>plants</u> as a residual, a catch-all for otherwise unclassified specimens. Residual categories do not fit into the hierarchical scheme and are discussed below.

I have determined that the following categories qualified as life forms at least part of the time: <u>trees</u>, <u>bushes</u>, <u>flowers</u>, <u>plants</u>, <u>grass</u>, <u>vines</u>, <u>cactus</u>, <u>weeds</u>, <u>fruits</u>, and <u>vegetables</u>. A few other categories may also have qualified as life forms but were used so seldom that not enough data were available for analysis. My rationale for determining what categories qualified as life forms is discussed below.

At least six informants had intermediate categories below the life form level, typically under <u>trees</u> and <u>flowers</u>. Virtually all generic classes were terminal. Only a few informants provided one or two specific names for plants.

Figures 4-14, below, represent the folk botanical classification schemes of the informants.

Figure 4. Informant 1, Model A, with a unique beginner, & model B, without a unique beginner

Figure 5. Informant 2, with a unique beginner

Figure 6. Informant 3, without a unique beginner

Figure 7. Informant 4, models with and without a unique beginner

Figure 8. Informant 5, Model A, with a unique beginner

Figure 9. Informant 5, Model B, without a unique beginner

Figure 10. Informant 6, Model A, with a unique beginner

Figure 11. Informant 6, Model B, without a unique beginner

Figure 12. Informant 7, without a unique beginner

Figure 13. Informant 8, Models A and B

Figure 14. Informant 9, with a unique beginner

Note: Figures 4-18, below, are photocopied from the original dissertation book.

Model A.

Level 0   Plants(UB)

Level 1   cactus(lf)   flowers(lf)   trees(lf)   bushes(lf)   grass(lf)   crops(lf)

                                                 ivy or   weeds(lf)
                                                 vines(lf)

- -

Model B.

Level 0   Trees(pseudo-UB)   Real Plants(pseudo-UB)

Level 1   trees(lf)   bushes(lf)   flowers(lf) crops(lf) vegetables(lf)

                                       wildflowers(i) garden   water plants(lf)
                                                flowers(i)

Level 2   acorn(g) pine tree(g)   dandelion(g) bluebonnets(g)

Level 3   Texas wild
                                                rice(s)
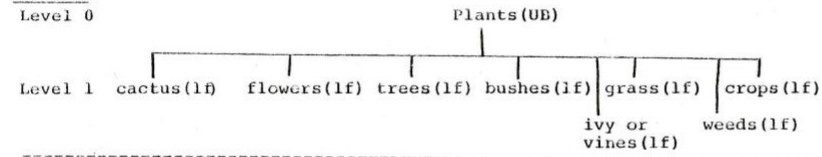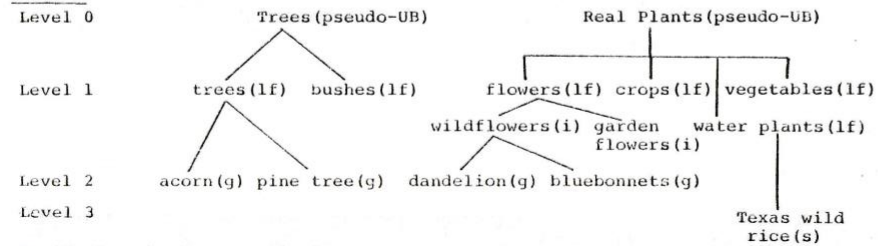
Residuals - bushes, small plants, grass, weeds

Categories with 0 or 1 named members - bushes, small plants, cactus

Figure 4. Informant 1. Model A - with a unique beginner. Model B - without a unique beginner.

Level 0   Plants (UB)

Level 1   flowers(lf) trees(lf) bushes(lf) weeds(lf) potted   grass(lf)
                                                              plants(lf)

                                                   ivy or   plants in or
                                                   vines(lf)   by rivers(lf)

Level 2   daisy(g) bluebonnets(g) cactus(lf/g?)

Residuals - regular plants, weeds, bushes

Categories with 0 or 1 named members - potted plants, grass, cactus, regular

plants

Figure 5. Informant 2, with a unique beginner.

Level 0   Trees (pseudo-UB)   Flowers & Plants (pseudo-UB)

Level 1   trees(lf)   bushes(lf)   flowers   cactus(lf) grass(lf)
                                                & plants(lf)

                                                             vines(lf)

Level 2   pecan(g) cedar   fern(g) rose(g) daisy(g) ivy(g)
                     tree(g)

Level 3   Texas bluebonnets(s)

Residuals - plants, weeds
Categories with 0 or 1 named members - cactus, plants, ivy, vines, weeds

Figure 6. Informant 3, without a unique beginner.

Model A.

Level 0   Plants (UB)

Level 1   poisonous | vegetables   fruits   wild   vines trees   flowers   water land
(1f)   plants   plants plants

                      miscellaneous

               animals   things unnamed

Model B.

Level 0   Trees(pseudo-UB)   Plants (pseudo-UB)

Level 1   trees   trees   bushes   plants   plants &   plants grass flowers
(1f)   with   with   trees by
                  flowers   prickly water
                                   stuff

Level 2   cactus   yucca   trees with   prickly stuff   droopy
                   (g)   (g)   prickly stuff   with flowers in   ones
           pecan   mimosa   the picture
           tree(g) tree(g)   daisy(g) tulip(g)

Residuals - trees with flowers, plants, grass, weeds, plants & trees by water

Categories with 0 or 1 named members - plants, weeds,   plants & trees
         by the water, vines, cactus, bushes, trees with flowers

Figure 7. Informant 4, models with and without a unique beginner.

Model A.

Level 0   Plants(UB)

Level 1   trees | bushes | flowers   wildflowers | weeds | fruits | vegetables
(1f)
           grass   houseplants   river   ivy or   cactus
                                         plants   vines
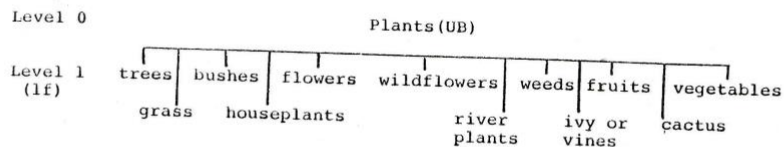
Residuals - bushes, plants, grass, cactus

Categories with 0 or 1 named member - none

Figure 8. Informant 5, Model A, with a unique beginner.

Model B.

Level 0   Trees (pseudo-UB)   Plants (pseudo-UB)   Flowers (pseudo-UB)

                                                                 flowering
                                                                 weeds (i)

Level 1   trees (lf)   pine trees   regular   wildflowers weeds
                       & coniferous (lf/i)   flowers (lf) (lf)   (lf)

          houseplants   bushes   river   ivy or   wild
          (lf)   (lf)   plants (lf) vines (lf) plants (lf)

Level 2   reeds (g)   elephant
                                             ears (g)

Figure 9. Informant 5, Model B, without a unique beginner.

Model A.

Level 0   Plants (UB)

Level 1   trees   bushes   flowers   water   cactus   weeds   vines   grass   fruit-bearing
                                     plants   or ivy   bearing
                                                                               plants
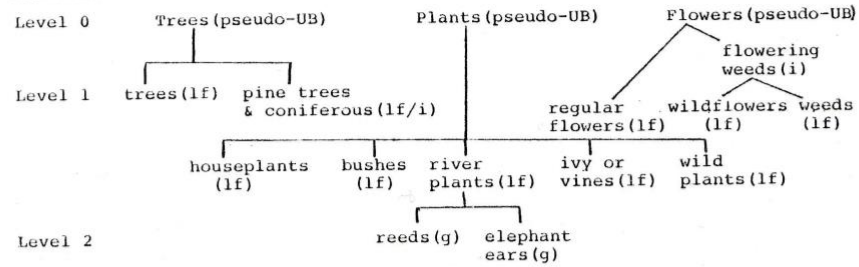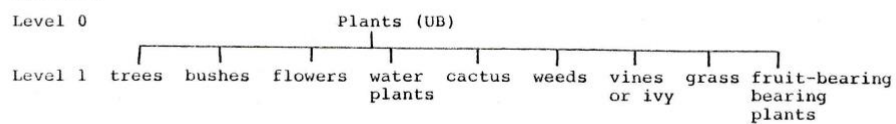
Residuals - bush, plants, cactus, leaves

Categories with 0 or 1 named members - water plants, cactus, grass, leaves,
        just plants

Figure 10. Informant 6, Model A, with a unique beginner.

Model B.

Level 0   Trees(pseudo-UB)   Plants(pseudo-UB)

Level 1   trees(lf)   bushes(lf)   flowers water   vines   cactus weeds
                                        (lf)   plants or ivy (lf)   (lf)
                                             (lf)   (lf)   grass(lf)

           conifer(i) deciduous(i)   wildflowers(i) not wild
                                               flowers(i)

Level 2   maple(g) oak(g)   tulip(g) carnation(g)

Level 3   silver maple(s)

Figure 11. Informant 6, Model B, without a unique beginner.

Level 0   Trees(pseudo-UB)   Plants(pseudo-UB)

Level 1   trees(lf)   bushes(lf)

                                  flowers plants grass cactus vines
                                   (lf)   (lf)   (lf)   (lf)   (lf)

                                  wild   plants in or   plants that
                                  plants   at a house   float in the
                                                        river

Level 2   acorn pine tree
           (g)   (g)
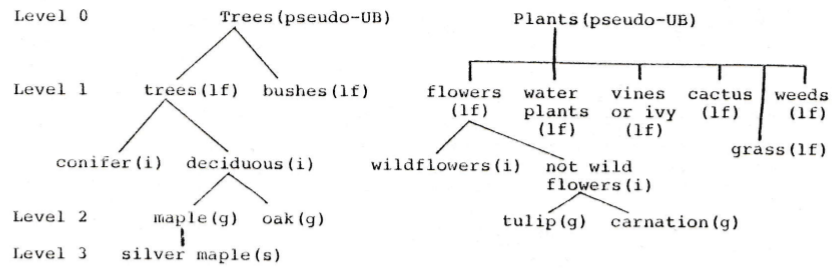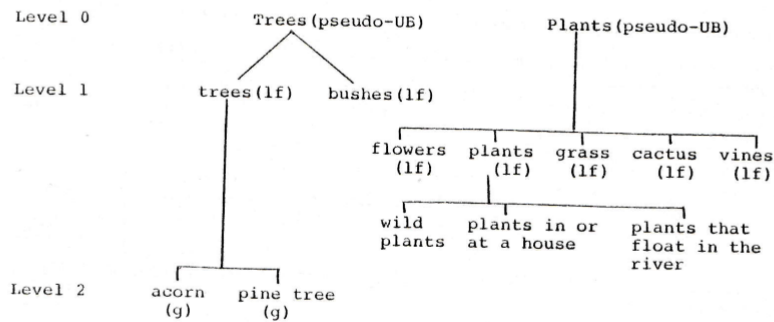
Residuals - plants, grass, weeds

Categories with 0 or 1 named members - cactus, wild plants, plants in or at
    a house, plants that float in the river

Figure 12. Informant 7, without a unique beginner.

Model A.

Level 0   Trees (pseudo-UB)   Plants (pseudo-UB)
                              | |
Level 1   trees(lf)   grass(i/lf)
                          /   \ |
                  conifers(i)   deciduous(i) |
                    /   \ |
Level 2   fir(g)   pine(g)   weeds(g)   flower(lf)   herbs(g)
                                                       /   \
                                            wildflowers(i)   flowers(i)
                                                                  /   \
Level 3   rose(g) daisy(g)

Model B.

Level 0   Plants(UB)
                          _____|_____
                         | | |
Level 1   flowers(lf)   trees(lf)   short plants(lf)

Residuals - bushes, plants, grass, weeds, cactus

Categories with 0 or 1 named members - plants, grass, cactus, weeds

Figure 13. Informant 8, Model A, early interviews without a unique beginner;
Model B, late interviews with a unique beginner.

Level 0   Plants(UB)
          _____|_____
         | | | | | | |
Level 1 trees   grass   flowers   bush   cactus fruits   vegetables
        (lf)   (lf)   (lf)   (lf)   (lf)   (lf)   (lf)
        / \   /   \ | |
  trees(i) pine tree flowers wildflowers plants under vines
Level 2   or evergreen(i) (i) or weeds(i) water(lf) or ivy(lf)
        / \
Level 2 oak(g) maple(g)   rose(g)   bluebonnet(g)
                                |
Level 3   red rose(s)

Residuals - bushes, plants, weeds, leaves

Categories with 0 or 1 named members - weeds, bushes

Figure 14. Informant 9, with a unique beginner.

Comparison with Adult Classification Schemes

As the informants did not use a scientific classification scheme, this researcher decided to compare her own folk scheme with that of the students (see Figure 15, below). The informants' models differed in several areas. I used plants as a unique beginner, not as a life form or intermediate. I acknowledged overlap between my folk categories and understood that members of folk categories overlap with members of scientific categories. I did not combine structurally defined categories with categories defined by usefulness (fruits, vegetables) or other subjective criteria (weeds).

This researcher's model resembled the children's models in several ways. Some names for major plant categories were the same (tree, vine, cactus). As do some informants, the researcher tended to include only the seed-bearing plants as plants, a botanically inaccurate overdiscrimination. She did not think to include ferns and other spore-bearing plants in her model. Atypical specimens, such as yuccas, might be thought of as shrubs or as plants, thus the researcher had a tendency to use plants as a residual.

The textbook used a folk classification scheme in grade three and a scientific scheme in grade four. Refer to Figures 16 and 17, below, for models of the schemes used in the text. In presenting the plant classification scheme the textbook started from the most abstract level, plants, in the first grade. In grade four the textbook moved through the most abstract levels of the scientific hierarchy down to monocots and dicots, but never mentioned the levels of family, genus, and species.

Although some informants' plant classification schemes were reasonably well-developed, few seemed to know how to make their tacit hierarchies explicit. Nothing in the textbooks could assist them in overcoming the discrepancies between their folk schemes and the scientific classification scheme. For example, several students included the categories fruits and vegetables (based on use) and the category weeds (based on subjective criteria) in the same hierarchical framework as the categories based on structure (e.g., tree and bush).

Figure 15. Model of Tull's folk botanical classification scheme

```
Level 0                                          Plants(UB)
                          ┌──────────────┬──────────┬────────┬──────────┐
Level 1          trees(lf)       shrubs(lf)  herbaceous  vines(lf)  cacti(lf)
                  ┌────┐                      plants(lf)
            non-conifers  conifers                                       │
                (i)         (i)
              ┌────┐       ┌────┐                              ┌─────────┐
Level 2   maple   oak   pine  juniper                    claret cup  prickly pear
           (g)    (g)   (g)    (g)                          (g)          (g)
               ┌──────┐                                              ┌────────┐
Level 3     live     bur                                      Engelmann's  purple-spined
           oak(s)   oak(s)                                     prickly      prickly
           ┌──────┐                                            pear(s)      pear(s)
Level 4  plateau    coastal
        live oak(v) live oak(v)
```
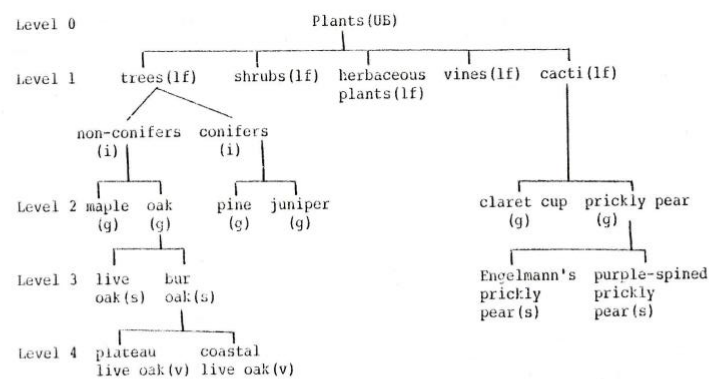
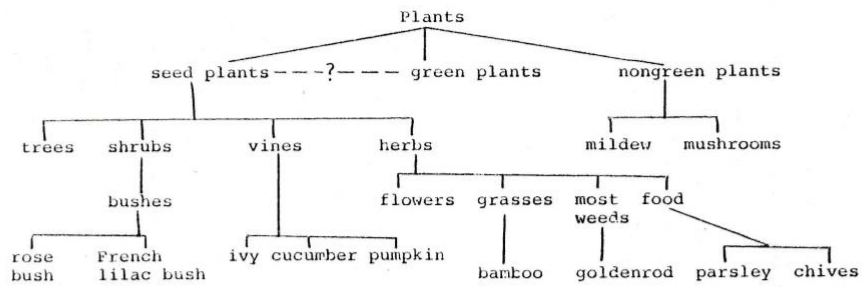Figure 15. Model of Tull's folk botanical classification scheme.

Figure 16. Folk botanical classification scheme depicted in Silver Burdett Science, grade three.

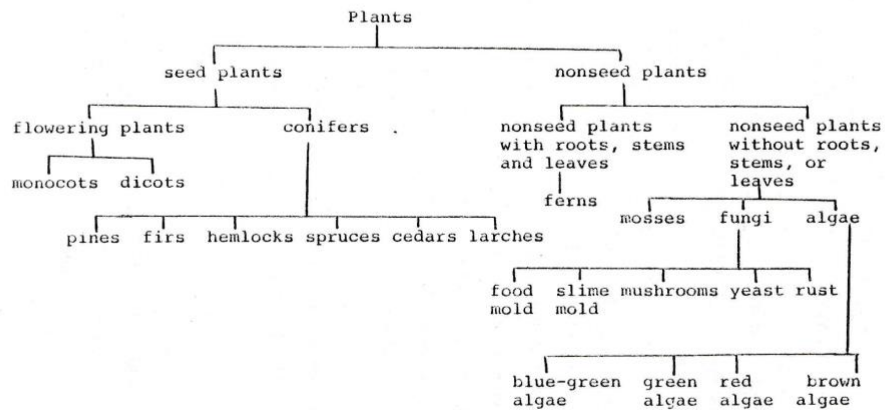Figure 17. Scientific botanical classification scheme found in Silver Burdett Science, grade four.

Figure 16. Folk botanical classification scheme depicted in Silver Burdett Science, grade 3

Figure 17. Scientific botanical classification scheme depicted in Silver Burdett Science, grade 4

Unique Beginners

In studies in various languages Berlin et al. (1974) found that even though individuals clearly distinguished between plants and animals, in some cultures individuals had no label for the abstract concepts, <u>plants</u> and <u>animals</u>. The current research suggests that many children in the United States may also lack a name for <u>plants</u> at the taxonomic rank of unique beginner. The category <u>plants</u> was rarely used in an all-encompassing manner, even by those who knew that it could be used that way.

At least seven informants demonstrated a tendency to divide all plants specimens into two large groups, the groups either implied or explicitly labeled <u>plants</u> and <u>trees</u>. Within the broad category <u>plants</u>, several life form categories were included. If <u>trees</u> was similarly subdivided into <u>trees</u> and <u>bushes</u>, the division was not explicit. Of the three informants who did not initially know that trees are types of plants, one changed her classification during the interviews and the others did include various woody specimens under <u>plants</u>. Thus it is possible that these students were in a transitional stage and that they will soon all include <u>trees</u> within <u>plants</u>. Evidence that <u>plants</u> remains polysemantic among some adults indicates that some children may not ever lose their multiple meanings for the category.

Because for these informants <u>trees</u> and <u>plants</u> seemed to share the top of the hierarchy, I have chosen to refer to these two categories as <u>pseudo-unique beginners</u>. In the models (Figures 4-14) the categories <u>trees</u> and <u>plants</u> may also be included as life forms below the level of pseudo-unique beginner.

True Life Forms

In the listing tasks, for only four categories did informants provide lists with numerous named members: <u>trees</u>, <u>flowers</u>, <u>fruits</u>, and <u>vegetables</u> (Table 4). The members of the categories <u>trees</u> and <u>flowers</u> were named and/or described more frequently than any other categories. All four categories were named with primary lexemes, an indicator that the names were generic names. Using Berlin's linguistic guidelines <u>fruits</u>, <u>vegetables</u>, <u>trees</u>, and <u>flowers</u> all qualified as true life forms (Berlin, 1976. The linguistic guidelines are explained in Chapter II, "Names for Plants").

Berlin considered that any category with two or more named generic members qualified as a true life form. In the current study the categories <u>plants</u>, <u>bushes</u>, <u>vines</u>, <u>grass</u>, <u>weeds</u>, <u>leaves</u>, and <u>cactus</u> usually had few named members named with primary lexemes (generics).

For a few informants one or more of the folk categories <u>plants</u>, <u>bushes</u>, <u>vines</u>, <u>grass</u>, <u>weeds</u>, <u>leaves</u>, and <u>cactus</u> had no or only one named generic member. <u>Grass</u>, <u>bushes</u>, and <u>vines</u> sometimes were

named strictly with secondary lexemes. By Berlin's linguistic guidelines, level 1 categories with fewer than two named members should be considered generic classes. Categories named strictly with secondary lexemes also should be classified as generics. Despite this, I have speculated that in this study, all except leaves behaved as life form categories at least part of the time. For several informants leaves and weeds acted strictly as residuals.

The discussion below presents this researcher's speculations on how to classify these plant categories (refer to "Residual and incipient categories" and "Cognitive differentiation").

Residual and Incipient Categories

Even though lacking named members the categories grass, bushes, cactus, vines, and sometimes plants and weeds typically appeared at the same hierarchical level as trees and flowers. They seemed to act psychologically as major plant categories. For several informants bush, grass, and/or cactus were polythetic categories and consistent with a botanist's usage. All these factors indicated that these categories qualified as true life forms.

C.H. Brown (1984) described categories that include only unnamed members as "incipient" life forms, embryonic categories that will become full-fledged life forms late in the development of a language as named members are included. Unlike the young children in Chase's study (C.H. Brown, 1984, discussed in Chapter II, "Names for Plants") these informants were old enough to know that a duck is a kind of a bird, and that an oak is a kind of tree. These informants did recognize set inclusion. Developmentally they had exceeded the incipient stage. In addition, in the folk nomenclature of the botanist, all the plants included in this study could be named at the generic and specific levels and could be included under a folk life form. Thus these categories cannot be considered incipients. The problem was not that the adult language lacked names for these plants, it was that these individuals lacked names for these plants.

Hunn (1982) considered that a category with no named generics is a residual, and may never be a true life form. Residual categories do not fit into Berlin's hierarchical model because set inclusion is lacking. According to Hunn a residual category represents empty taxonomic space and serves linguistically "as a means to dismiss all organisms not worth recognition on their own account" (p. 834).

In the current research, the informants seemed to use several categories as residuals from time to time (refer to Table 3). Plants, bushes, cactus, grass, weeds, and leaves seemed to serve as dumping grounds for otherwise unclassified specimens. Some members selected for these categories matched the prototype but for several specimens in each category selection was inconsistent and seemed arbitrary, indicating that it was not based on a prototype. Some specimens seemed to be placed in these residual categories by default. For example, a flowering herb was almost always called a flower but when the flower was gone, the specimen might be labeled as either a plant, grass, weed, or leaves. Thus these categories seemed to serve as dumping grounds for specimens that did not clearly match the prototype flower. Refer to the section "Categories for Plants" for a discussion of the relationship of differential salience and

residual categories.

According to Hunn (1982) members of a residual category are alike "only by virtue of having been passed over in the process of cultural recognition" (p. 834). One would not expect a residual category to be based on a prototype or to have any named members. One would expect suprageneric levels of abstraction to be salient in classifying residuals. In the current research, however, most categories seemed to be based on a prototype and even the categories that served as residuals might have a few named members. Informants demonstrated ability (and interest in) distinguishing between members of a category (e.g., types of <u>cactus</u>) even when lacking names for those members (refer to "Cognitive Differentiation", below). Thus even though acting as residuals part of the time, these categories also seemed to serve as life forms part of the time.

These categories did not fit either Berlin's, Brown's, nor Hunn's models. How should they be classified? I have speculated that for these children (and probably for the adult layman as well) categories lacking named members represent a late stage in cultural development rather than an early stage. In the adult lay culture, these categories do have (or used to have) named generic members. As the culture becomes more technologically advanced, a diminishing reliance on wild plants has resulted in loss of knowledge of generic names.

Whereas an incipient life form is thought to develop early, prior to the development of a true life form (with named members), these unnamed categories formed late, after the development of true life forms. As individuals in a society lose knowledge of the generic and specific names for plants, the result will be life form categories with fewer and fewer named members. The author has suggested that for these individuals some specimens (both named and unnamed) were chosen on the basis of resemblance to a prototype and some specimens (both named and unnamed) were arbitrarily placed in a residual category when the individual was uncertain how to classify them.

In this study, major plant categories included both named and unnamed members, members that matched a prototype and members that did not. The result was a polysemantic category, serving as a true life form part of the time and as a residual part of the time.

<u>Cognitive Differentiation</u>

In a residual classification, one would expect suprageneric levels to be used in naming specimens. A specimen relegated to a residual category is in essence unclassified. The individual seems to ignore attributes that differentiate specimens on a generic or specific level. The informant either does not know how or does not care to distinguish between specimens at the generic level of abstraction. For example, in this study several informants stated that a bush is "just a bush" and a grass is "just a grass." They did not bother to differentiate the specimen from other types of bushes or grass.

Dougherty (1979) observed, however, that children sometimes differentiate between specimens even when lacking generic names. Through use of description, her children provided evidence of cognitive differentiation when lacking the knowledge required for linguistic differentiation. For

example, she found that children were able to describe differences between trees for which they had no names.

The informants in the current research also displayed cognitive differentiation in some categories lacking named generic members. For example, informant 6 designated specimens as "most like" and "least like a cactus," even though she had a generic name for only one type of cactus, the prickly pear.

The fact that the children chose to differentiate between these unnamed specimens indicated that these specimens were not regarded as residuals. The children demonstrated the ability and the desire to differentiate between some unnamed specimens below the life form level (taxonomic level 1). Using Hunn's definition, they would not be considered residuals because they had not been dismissed as though they were unworthy of recognition.

Lack of linguistic differentiation, therefore, was not always due to lack of ability or interest in differentiating between members of a category. It was sometimes the result of a lack of linguistic information. Cognitive differentiation existed even though linguistic differentiation did not.

Thus this researcher has suggested that some categories with few or no named members qualified as true life forms. Several informants chose to differentiate (by use of description) the following categories below taxonomic level 1: bush, cactus, grass, and vines. Unfortunately, lack of linguistic knowledge sometimes masked evidence of cognitive differentiation. Even when it was not clear that informants were differentiating below level 1, that informants seemed to rely on prototypes for category selection indicated that the following categories qualified as true life forms for some individuals even when lacking named members: bush, plants, grass, vines, cactus, and weeds.

Intermediate Categories

In addition to the life form and generic levels, several students classified some specimens at intermediate levels of abstraction. Six informants divided the life form flowers into "wildflowers" and "garden flowers," although inconsistently. Though the prototype tree was always a deciduous broadleaf tree (e.g., maple), three informants (5, 6, and 8) used the term "conifer" to distinguish the coniferous trees. These intermediate categories all included members named with primary lexemes (generics), thus they were not terminal categories.

"Wildflowers," "flowers," "conifers," and "deciduous trees" would all be used in a similar manner by adult laymen. "Conifer" was included in the scientific classification scheme presented in the elementary textbook, grade four. The informants generally used "conifer" accurately.

Informant 9 also divided the trees into two groups but lacked the appropriate terminology. He called the conifers "pine tree or evergreen." He distinguished between pine trees and evergreens on a generic level. Although several informants overgeneralized the label "pine" to include various conifers, the same informants also had other generic names for "conifers" (e.g., "spruce" and "fir"). Thus these informants probably were not using "pine" as an intermediate label.

Informant 4 had some idiosyncratic categories. In addition to trees, he used the categories "trees with flowers" and "plants and trees by the water" at taxonomic level 1. When asked to include with trees all of the trees, he moved most (but not all) of the trees out of the other categories. Thus he apparently did recognize trees as inclusive of his other tree groups. He placed "cactus," "yuccas," and several other thorny plants in a category labeled "things with prickly stuff on it." It was not clear whether "prickly stuff" was an intermediate category elevated above the life form cactus or whether cactus should be viewed as a generic for this informant.

Several informants had categories at taxonomic level 1 that were labeled "something plant": Informant 1 had "small plants" and "water plants"; informant 2 used "plants in or by rivers"; informant 5 used "river plants," "wild plants," and "houseplants"; informant 6 had "water plants" and "just plants"; informant 7 had "wild plants," "plants in or at a house," and "plants that float in the river"; informant 8 had "short plants"; informant 9 had "plants under water."

Plants seemed to behave as a pseudo-unique beginner elevated above these categories. These plant subsets might all be thought of as life forms at taxonomic level 1 (except for a few, e.g., "small plants" and "just plants," that served strictly as residuals). Thus these categories may not be intermediate categories.

Informant 1 used "dandelion" to include a number of similar looking members of the sunflower family. Dougherty (1979) might consider this an elevation in rank from a generic to an intermediate level. But in this case, overgeneralization of the generic "dandelion" seemed to be an attempt to avoid using an abstract designation for plants that the informant was able to differentiate at the generic level. Thus "dandelion" was a generic label, not an intermediate. Adults in the US tend to use the term Damned Yellow Composite (DYC) for any species that looks like a dandelion.

When lacking an accurate generic name, informants frequently substituted the known generic name of a similar species. In adult lay usage, generics such as "daisy" and "pine" are often used to refer to more species from than one genus. For example, adults tend to call pine, fir, and spruce trees all "pines." The children may have preferred an erroneous generic name over a more abstract life form name if the generic name reflected their cognitive ability to differentiate. With these children, overgeneralization at the generic level did not necessarily imply inability to discriminate between different species. Rather, it could be viewed an indicator that the individual was able to discern similarities between different species. This ability is a key to the learning of botanical family and genus groupings, an ability that has been overlooked in the elementary textbooks.

Most intermediate classification occurred between the life form and generic levels. Informant 8 seemed to have an intermediate classification elevated above the life form level. She used grass to include various herbaceous categories (weeds, flowers, herbs). Of these categories, only flowers had named members and clearly served as a life form. The other three may have served strictly as residual categories for small plants. This informant overgeneralized grass to include various

unnamed non-flowering herbs and showed little interest in differentiating any further. For her, the hierarchical relationships of these categories was ambiguous and probably fluctuating. Her herbaceous categories were poorly defined. She may have had little idea how to distinguish between them.

Children's Plant Classification Schemes: Summary

The children's folk classification schemes differed from the scientific scheme used by botanists. The children did not use names for the abstract levels of the scientific scheme (e.g., monocot, dicot). The students tended to use a binary division of plants, with <u>trees</u> and <u>plants</u> forming what I have called pseudo-unique beginners.

The category <u>plants</u> was polysemantic for most informants. Hierarchical relationships therefore fluctuated somewhat. Although differing from that of botanists, the children's classification schemes may be similar to those of adult laymen. Some similarities were found with the folk classification model of this researcher (a botanist). Berlin (1976) points out that folk classification schemes typically have similarities with scientific schemes at the lower levels of the hierarchy. At the generic and specific level, the folk divisions are often very similar to the scientific divisions for genus and species.

<u>Trees</u> and <u>flowers</u> qualified as true life forms using Berlin's linguistic guidelines. The categories <u>bushes</u>, <u>plants</u>, <u>vines</u>, <u>grass</u>, <u>weeds</u>, and <u>cactus</u> seemed to also behave as life forms even though they often lacked named members. <u>Leaves</u> seemed to act strictly as a residual. Several categories included both named and unnamed members, members that matched the prototype and members that did not. These were polysemantic categories, serving as both life forms and residuals.

With some categories (e.g., <u>cactus</u>) informants demonstrated an ability and a desire to differentiate specimens at the generic level of abstraction even when lacking knowledge of names. Thus, the children were able to differentiate cognitively even when they could not differentiate linguistically.

Several students classified specimens at intermediate levels between the life form and generic levels. Contrary to the conclusions Dougherty made with her study, in the current study there was no evidence that intermediate categories replaced generic level categories. Most intermediate categories had members named at the generic level of abstraction. One informant may have had an intermediate category above the life form level.

Section 3: Names for Plants

In this section are examined the responses children gave when asked for the names of plants. The questions of interest for this section were: what are the children's names for plants; what types of

plant names do children remember; when children do not know the names for plants, how do they respond; what level of abstraction is psychologically basic for children when naming plants.

In the process of analysis several topics of interest were uncovered: avoidance strategies that affect how children respond when they do not know the names for plants; and diverse types of errors made when naming plants.

Section 3 has been divided into the following three subtopics: "The Listing Tasks," "Types of Responses and Basic Level of Abstraction in Naming Plants," and "Types of Errors."

The Listing Tasks

Level 1 Assertions

The children were asked to list from memory all the types of <u>trees</u>, <u>bushes</u>, <u>flowers</u>, and other categories the child used. For only four categories, <u>trees</u>, <u>flowers</u>, <u>fruits</u>, and <u>vegetables</u>, did the informants make a substantial list of generic names.

I examined the types of names that children remembered. Table 4 has included a summary of the types of names given for <u>trees</u>, <u>flowers</u>, <u>fruits</u>, and <u>vegetables</u>.

55% of the names for <u>trees</u> referred to trees with edible or useful products (e.g., apple tree, pecan trees) and 28% are commonly used as ornamentals (maple, pine). Only 7% were non-ornamental wild trees. 46% of the <u>flowers</u> named have ornamental value (rose, tulip) and 17% have other economic value ("peach bud, orange bud"). 32% were local wild herbs with showy flowers (bluebonnet, buttercup, dandelion).

Level 2 Assertions

The data have indicated that children remember best the names of plants that are useful to humans.

Table 4: Number of Edible or Useful, Ornamental or Wild Plant Names Given by Children in a Listing Task

	Informant Identification Number									
Type of Name	**1**	**2**	**3**	**4**	**5**	**6ª**	**7**	**8**	**9**	**Total**
Trees										
• Edible or Useful	0	5	7	9	9	-	10	7	5	**52**
• Ornamental	4	1	3	4	4	-	1	6	4	**27**
• Wild, local	1	1	1	1	1	-	0	1	1	**7**
• Other	2	2	0	0	1	-	1	1	2	**9**
Flowers										
• Edible or Useful	0	0	0	0	2	-	2	8	1	**13**
• Ornamental	5	4	4	4	4	-	5	5	6	**37**
• Wild, local	2	6	1	4	6	-	0	3	3	**25**
• Other	0	0	2	0	0	-	0	0	1	**3**
Vegetables	11	-	6	13	-	-	12	36	23	**91**
Fruits	7	-	9	16	-	-	15	35	23	**95**

Note: a = No data available

Types of Responses and Basic Level of Abstraction in Naming Plants

Level 1 Assertions

The nine informants were asked to name a wide variety of plants, viewed in slides and in the outdoor sessions. Appendix A-6 has summarized the types of names (life form, generic, or specific names) and other responses each informant gave when asked to name plants seen in slides and in the outdoors. In Appendix C-1 the transcripts of one informant's responses to the slide sets have been placed. In Appendices C-3 and C-7 have been placed the transcripts of one informant's outdoor sessions.

When the informant did not know the correct generic name, he or she was forced to give an alternate response. Substituting a life form (or other suprageneric name) was one possible alternative. Analysis of the data revealed that the child might resort to other types of responses as well. The response types given by the 12 year old children in this study could be summarized as follows: correct generic responses, incorrect generic responses (including made-up names), specific names (correct or incorrect), correct or incorrect life forms (or other suprageneric names), and non-name responses (a description given with or without a name, no response, or the response, "I don't know").

The percentage of generic and life form (or other suprageneric) names used by each informant is

presented in Table 5. All the children used generic names for a significant portion of their responses (25-63%). All informants had a poor knowledge of correct generic names for plants, however. No one had more than 32% correct generic names and five informants had fewer than 20% correct generic names. No one used more than one or two specific names in all of their responses.

All informants also gave a significant number of life form (or other suprageneric) names (from 15-65% of all responses).

Below is an explanation for the rows on Table 5. The designation life form includes all suprageneric responses.
- Row 1 - percent life forms = (the number of suprageneric names) divided by (the number of plants viewed)
- Row 2 - percent correct life forms = (the number of correct suprageneric names) divided by (the number of plants viewed)
- Row 3 - percent of simple life forms = (the number of suprageneric names given without descriptive information) divided by (the number of plants viewed)
- Row 4 - percent generic responses = (the number of generic names) divided by (the number of plants viewed)
- Row 5 - percent correct generics = (the number of correct generic names) divided by (the number of plants viewed)
- Row 6 - percent incorrect generics = (the number of incorrect generic names) divided by (the number of plants viewed)
- Row 7 - total percent correct = (the number of correct generic names plus correct suprageneric names) divided by (the number of plants viewed)
Table 5: Percentage of Generic, Life Form, and Other Suprageneric Names for Plants Viewed in Slides and Outdoors

Informant Identification Number																		
% Response Type	**1 S**	**1 O**	**2 S**	**2 O**	**3 S**	**3 O**	**4 S**	**4 O**	**5 S**	**5 O**	**6 S**	**6 O**	**7 S**	**7 O**	**8 S**	**8 O**	**9 S**	**9 O**
Life Form	45	54	40	49	15	35	55	35	17	39	31	45	57	65	60	58	17	31
Correct Life Form	23	39	29	43	15	33	45	32	26	27	20	41	54	57	49	42	14	26
Simple Life Form	45	25	29	13	15	31	54	22	17	23	20	14	45	55	57	50	17	21
Generic	52	44	32	31	51	27	32	35	42	40	63	38	37	31	37	25	54	40
Correct Generic	23	24	12	17	12	17	15	28	25	27	32	16	14	8	20	17	17	12
Incorrect Generic	29	20	20	14	38	10	17	7	17	14	31	22	23	22	17	8	37	29
Total % Correct	46	69	42	60	26	50	60	57	51	54	52	58	68	65	69	58	31	38
Non-name Reponses	3	2	28	20	34	38	12	30	22	21	6	16	6	4	3	17	29	29

Note: S=Slide Task; O=Outdoor task

Table 6 (below) presents the number of cases in which each informant uses various response types: specific names, made-up generics, a suprageneric name with a description, a description without a name, no response, or says, "I don't know."

Table 7 (below) summarizes the data from Table 5. Table 7 indicates how many children used life form and generic names more than 30% of the time, and how many used correct and incorrect generics more than 20% of the time. Row 3, "Average" was based on an average of the percentages from both types of tasks (slides and outdoors).

Table 8 (below) summarizes the data from Table 6. Table 8 shows how many children used each response type more than five times. I arbitrarily chose 20%, 30%, and "five times" as cut off points for purposes of demonstrating how many children used each response type on a fairly regular basis.

Table 6: Number of Cases in Which Informant Uses Various Response Types in Slide and Outdoor Tasks

	Informants																	
	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9
Response Types	S	O	S	O	S	O	S	O	S	O	S	O	S	O	S	O	S	O
Made-up Generics	3	3	5	0	17	2	1	1	1	2	2	1	7	8	3	3	12	8
Specific Responses	1	0	0	1	1	2	0	0	0	1	0	0	0	0	0	0	1	1
Life Forms described	0	17	7	31	0	2	1	9	13	7	7	23	8	5	2	4	0	4
Description Alone	0	1	3	13	1	8	0	8	4	4	3	10	4	2	1	3	2	9
Says, "I don't know."	2	0	14	4	0	5	8	14	10	10	14[a]	2	0	0	0	5	0	3
No Response	0	0	0	0	20	5	0	0	0	0	0	0	0	0	0	0	16	0

Note: S=Slide Task   O=Outdoor Task
      a= Only when giving a name

Table 7: Number of Informants Using Life Form and Generic Names More than 20-30% of the Time

Response Type				
Type of Task	Life Form[a]	Generic[a]	Correct Generic[b]	Incorrect Generic[b]
Slides	7	8	4	9
Outdoors	9	7	3	8
Average	9	9	4	9

Note:
    a> 30% of responses
    b> 20% of responses

Table 8: Number of Informants Using Various Response Types More than Five Times

Type of Task	Response Type				
	Made-up Generics	Life Forms Described	Description Alone	"I don't know"	None
Slides	4	4	0	4	2
Outdoors	2	6	5	4	1

Comparing slide sets I and II

Level 1 assertions.

The plant species used in the slide sets have been listed in Appendix A-1. The species chosen were common to central Texas. I chose 17 slides for set I (out of 34 species) that I predicted would be difficult for the informants to identify at the generic level. These 17 slides were either of the whole tree, shrub, or other type of plant from a distance or of a plant or plantlike object known to be difficult for adults to name (e.g., lichen, ragweed).

As predicted, students did not have correct generic names for the 17 difficult species. Few informants gave generic responses for these slides. Either a more abstract name was given (e.g., tree, bush, flower) or a non-name response was given (e.g., the student said, "I don't know").

On the second set of slides (30 species), close-up shots were used, often coupled with distance shots. Close-up shots provided the viewer with greater detail thus should make identification easier. All of the informants used more generic names on the second set of slides than on the first set, even though many of the generic names they used were different from the common names used by botanists (see Appendix A-6). Even those informants who used suprageneric responses more often than generic names overall decreased their use of suprageneric and increased their use of generics from slide sets I to II.

Level 2 assertions.

The data indicated that when few details were available in a photograph, most students did not mind using a suprageneric response. When given more detail (as in the close-up photographs), however, the informant was not as likely to give an abstract response. In the second set of slides, more generic names were used even though most of the names were incorrect (i.e., differed from folk names that would be acceptable to a botanist). The results suggest that when viewing close-up photographs the informant was able to discriminate below the life form level. The informants seemed to prefer to respond with a name that matched the level of abstraction at which he or she could discriminate (the generic level) rather than a more abstract name.

Comparing data from outdoor sessions with slide data

Level 1 assertions.

The outdoor interviews served as a triangulating source of data for the more highly structured slide task. The results from the two types of data matched each other quite well (see Appendix A-6 and Tables 5 and 6). Similar trends (explained under avoidance strategies, below) emerged from both sets of data.

The outdoor interviews allowed me to examine in greater detail the children's use of names. If the informant responded with, "I don't know," I occasionally pushed for a named response by saying, "What kind of a thing is it?" On being forced the informant might then respond with a life form name or the individual might provide a description. Most of the children occasionally initiated their responses with, "I don't know what kind of tree it is." These types of responses provided direct evidence that the suprageneric response was not the first preference of the child.

In a few cases field results differed from slide task results. Some of those differences were predictable. About half the students gave a higher percentage of accurate generic names in the familiar settings of their own yard and neighborhood (Table 5, row 5). Besides familiarity, the additional detail available in the living specimens could also be expected to improve performance. Several students performed somewhat worse in the field. I had no theory for this anomaly. There were fewer incorrect generic responses in the field however.

In the outdoor interviews more descriptions were expected due to prompting by the researcher. Of the five individuals who rarely or never spontaneously added descriptive information to their suprageneric responses when viewing slides, two (informants 1 and 4) shifted that pattern in the field (Table 6).

In the slide task, no child responded with a description without a name more than five times (although five informants responded with a description rather than a name in three or four cases; see Table 6). In discussing children's tendencies to use descriptions when asked for plant names, I decided not to include the data from the outdoor sessions. The evidence indicates that prompting by this researcher probably influenced that data significantly. In discussing field data, the response type "description alone" has been counted only as a non-name response. In discussing the slide data, responses that include descriptive information have been included as that data were not contaminated by the researcher's prompting.

Spontaneous use of descriptive responses was frequent enough in the field to warrant further examination. The fact that four children did not alter this particular response type from slides to field may be an interesting phenomena to study further. The researcher would need to conduct outdoor interviews in which the researcher never asked for descriptive information.

<u>Level 2 assertions</u>.

Five children (informants 1,3,6,7,9) used a lower percentage of generics and a higher percentage of suprageneric responses in the field (Rows 1 and 4, Table 5). Comparison of data from slide sets I and II (above) indicated that when presented with greater detail, informants were more likely to give a generic response. Not enough data were available to determine the factors influencing this shift in response pattern from slides to field. If the informant did not already know the correct name, the additional details available in the field would not be an assistance in naming the plant. Perhaps in the field the informant was more certain that he or she did not know the correct generic and was, therefore, less likely to guess a name. In the field, informants 1 and 6 may have been replacing incorrect generics with described life forms (Table 6, row 3).

For these informants, the shift did not seem to affect their overall response pattern. Four informants (1,3,6,9) had a high percentage of generics in the slide task. For informants 3 and 9, the percentage of suprageneric names in the field remained quite low relative to other children. For these four informants, the shift was not significant when compared with the overall tendency to avoid an abstract response (see discussion of avoidance strategies, below). Informant 7 had a high percentage of suprageneric names in both tasks so his overall response pattern did not change.

<u>Basic Level of Abstraction: Level 2 Assertions</u>

If a child had a strong preference for using generic names ("oak" rather than "tree") we would expect that the individual would use a high percentage of generic names and a low percentage of life form or other suprageneric names. Only two informants (3 and 9) matched this expectation. All the children used generic names for more than 30 percent of their responses. Thus the generic level was linguistically salient for naming plants (i.e., frequency of use was significant for generics). Only four informants (1,3,6,9) used generic names for more than 50 percent of their responses, however, and all the children used life form or other suprageneric responses for a significant portion of their responses (from 15-65% of all responses). Refer to Table 5, rows 1 and 4 for a comparison of percentage of generic and suprageneric responses.

It was apparent that for these children the life form level also was linguistically salient in naming plants. For four informants (2,4,7,8), life form and other suprageneric responses were more frequent than generic responses in the slide task. Both generic and life form levels were used with enough frequency to indicate that they were both linguistically salient for naming plants. But how do these two levels of abstraction compare in psychological salience? For the answer to that question, I reviewed other aspects of the responses.

The children used a variety of response types when asked to name a specimen: specific responses, made-up generic names, added a description to a life form name, gave a description rather than a name, said, "I don't know," or gave no response (see Tables 6 and 8).

Specific names were used so seldom that they were not examined further. For purposes of percentage tabulations in Table 5, the number of specific names was lumped with the number of

generic names. Because the taxonomic ranking of some suprageneric names (e.g., <u>plants</u>) was sometimes ambiguous, all were lumped together and tabulated as life form names in Table 5.

All nine informants used incorrect generic names (guesses and/or made-up names) for more than 20% of their responses (see Table 7). Four informants used made-up generic names on a fairly regular basis. Five children gave non-name responses more than 20% of the time (Table 5).

Analysis of the data has indicated that a variety of concerns influenced how each individual responded. One or more avoidance strategies seemed to emerge for each individual.

<u>Level 3 Assertions</u>

<u>Avoiding an abstract response</u>.

The frequent use of guessed and made-up generic names suggested that the children preferred generic names to suprageneric names. The guesses often demonstrated knowledge of related species or similar forms (refer to "Types of Errors," below). Made-up generic names often were descriptive ("thorn plant") and some were compound names derived from life form categories ("wild plant tree," "cactus bush").

Several other response types resulted in a reduced reliance on life form names when generic names were not known. I have speculated that these response types may be related to a desire to avoid using abstract names when lacking knowledge of generic names. Four informants (3,5,6,9) used a relatively low percentage of life form names (15 - 40% of the responses).

In addition, informants 5 and 6 frequently augmented life form names with descriptive phrases (in both slides and field). Adding descriptive information enabled the informant to discriminate between members of a life form category (e.g., <u>trees</u>) when lacking a generic name.

I suggest that by adding a descriptive phrase to a life form name, the child has indicated a desire to identify the plant at a less abstract level. If (in slide tasks) the suprageneric names with descriptors are counted as equivalent to generic names, then the percentage of suprageneric names is reduced significantly (greater than 10%) for four informants (compare rows 1 and 3 in Table 5). For example, for informant 6, the percentage decreases from 31 to 20.

Giving non-name responses (e.g., saying, "I don't know," or providing a description rather than a name) also resulted in reduced numbers of suprageneric responses (although these response types can be the result of other concerns as well, see below).

In summary, the following response types may have been related to a desire to avoid an abstract response: low percentage of life form or other suprageneric names, moderate to high percentage of generic names (both correct and incorrect), the frequent use of made-up names, adding a description to a life form, giving a non-name response.

Table 9 (below) indicates which informants used these strategies in the slide or outdoor tasks. Six informants used a combination of three or more of these response strategies. Two others used two of these techniques on a regular basis. The only informant (number 8) who did not rely on these strategies to avoid an abstract response still used generic responses more than 30% of the time.

Table 9: Informants that Use Strategies to Avoid a Suprageneric Response

Response Type Used	Informant Identification Number								
	1	2	3	4	5	6	7	8	9
Moderate-High % Generics	Y	Y	Y	Y	Y	Y	Y	Y	Y
Moderate-High % Incorrect Generics	Y	N	Y	N	N	Y	Y	N	Y
Low % Life Forms	N	N	Y	N	N	N	N	N	Y
Described Life Forms[a]	N	Y	N	N	Y	Y	Y	N	N
Made-up Generics	N	Y	Y	N	N	N	Y	N	Y
Says, "I don't know"	N	Y	N	Y	Y	Y	N	N	N
No response	N	N	Y	N	N	N	N	N	Y
Description Alone[a]	N	N	N	N	N	N	N	N	N

Note: Low = ≤20%;   Moderate = 20-50%;   High = >50%
        a = Data from outdoor tasks not included

If avoidance of suprageneric responses was a concern of at least six students, then how can we explain the fact that the informants did use life form names on a regular basis? I have speculated that other concerns also influenced how the children responded when asked to name a plant.

Avoiding admission of ignorance and avoiding being wrong.

Several of the response strategies mentioned above also had the effect of protecting the informant from an admission of ignorance. Five students (1,3,7,8,9) never or rarely said, "I don't

know." For four of them (1,3,7,9) giving an incorrect generic name may have been preferable to admitting they did not know the correct generic name. Other techniques that would enable an individual to avoid admitting ignorance were: guessing or using made-up generic names; providing a description rather than a name or giving no response; substituting a life form name for a generic name. In this study, four informants used three or more of the above response types, indicating a desire to avoid admission of ignorance. Table 10 (below) shows the strategies used by each informant that would result in an avoidance of admitting ignorance.

To avoid admitting ignorance a student must often risk giving a wrong answer. Several of the response strategies also served to protect the child from giving a wrong answer. If the informant feared giving a wrong answer, he or she might avoid guessing or using made-up names. Thus the informant might have a low percentage of incorrect generic responses. Although informants typically performed poorly when giving generic names, most informants were able to get more than 80% of their suprageneric names (tree, bush, vine) correct. Informants 7 and 8 used suprageneric responses frequently. By substituting suprageneric names when they did not know the generic name, both were able to increase their percentage of correct responses by more than 40% (compare rows 5 and 7, Table 5). Their total percentages of correct responses (counting both generic and life form names) were the highest of any informants (68 and 69%). Both of these informants commonly used the abstract name plant as a response, which enabled them to give a correct response more frequently than those students who had a higher percentage of correct generic responses.

If the student equated admission of ignorance with giving a wrong answer, a high percentage of life form names might be preferable to saying, "I don't know." The children could also avoid giving a wrong response by providing a description rather than a name or by giving no response at all.

Table 10: Informants that Use Strategies to Avoid Admission of Ignorance

Response Type Used	Informant Identification Number								
	1	2	3	4	5	6	7	8	9
Moderate-High % Incorrect Generics	Y	N	Y	N	N	Y	Y	N	Y
High % Life Forms	Y	N	N	Y	N	N	Y	Y	N
Made-up Generics	N	Y	Y	N	N	N	Y	N	Y
Description Alone[a]	N	N	N	N	N	N	N	N	N
No Response	N	N	Y	N	N	N	N	N	Y
Does Not Say, "I don't know"	Y	N	Y	N	N	N	Y	Y	Y

Note: Low = ≤20%;   Moderate = 20-50%;   High = >50%
        a = Data from outdoor tasks not included

In summary, the following response types would enable an individual to avoid being wrong: if the child did not know generic names for plants, he or she might avoid using them and would have a low to moderate percentage of generic names; the individual would want to avoid guessed or made-up generic names, might have a high percentage of life form names, or might give no response or give a description rather than a name. Table 11 (below) shows which informants used strategies that would result in avoidance of being wrong.

Table 11: Informants that Use Strategies to Avoid Being Wrong

	Informant Identification Number								
Response Type Used	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Low-Moderate % Generics	N	Y	N	Y	Y	N	Y	Y	N
Low % Incorrect Generics	N	Y	N	Y	Y	N	N	Y	N
High % Life Forms	Y	N	N	Y	N	N	Y	Y	N
Does <u>not</u> use Made-up Names	Y	N	N	Y	Y	Y	N	Y	N
Description Alone[a]	N	N	N	N	N	N	N	N	N
No Response	N	N	Y	N	N	N	N	N	Y

<u>Note</u>: Low = ≤20%;   Moderate = 20-50%;   High = >50%
     a = Data from outdoor tasks not included

Three informants used three or more techniques that resulted in avoidance of giving a wrong answer. Six children used at least two strategies. For at least six informants, concerns about admitting ignorance and giving a wrong response seemed to affect their response patterns simultaneously.

The response types thought to be related to the three avoidance strategies had considerable overlap. To determine what concerns most strongly influenced the responses of each child, I examined the combinations of response types used by each.

Some response types were key indicators of a concern. For example, five informants rarely or never said, "I don't know." Two informants (3,9) frequently gave no response. These informants probably had major concerns about admitting ignorance.

On the other hand, four students (2,4,5,6) readily said, "I don't know." These four may have had concerns about admitting ignorance, but avoidance of abstract names seemed to be a greater concern.

A high percentage of life form names plus a low percentage of incorrect generic names (guesses and made-up names) indicated that the child had a major concern about giving a wrong answer.

Two informants (4,8) demonstrated this trend.

Two students (3 and 9) that showed marked tendencies to avoid life form names also displayed major concerns about being wrong or admitting ignorance (they rarely said, "I don't know," but regularly gave non-name responses). The combination of strategies used by informants 3 and 9 indicated that their preference for generic names outweighed their other concerns. They knew very few correct generic names. Nonetheless, they used fewer suprageneric names than any other informants. Though they could have dramatically increased the total percentage of correct answers by substituting life forms, they typically chose to give no response or to make up a generic name rather than give a more abstract name. They only used life form names when they were certain of being correct (100% of informant 3's life form names were correct).

Surprisingly, they rarely added descriptive information to the life form or generic names. These individuals frequently used made-up generic names that often were descriptive in nature, however.

For Informant 1, combined concerns about admitting ignorance and being wrong resulted in a high percentage of life form responses. She rarely said, "I don't know." She almost always gave a named response. Nonetheless, 52% of her responses to the slides and 44% of her responses outdoors were at the generic level. For her, generic names were salient although she also relied on life form names frequently to deal with her other concerns. She rarely used made-up names but she often guessed. Her guesses were well-informed guesses.

<u>Summary of Level 3 Assertions</u>.

Eight Informants demonstrated a desire to avoid abstract names for plants. Concerns about showing ignorance or being wrong affected their responses, however. Table 12 (below) shows what areas of concern were the greatest for each child. Six informants had major concerns about being wrong and four had major concerns about admitting ignorance.

Table 12: Children's Areas of Greatest Concern in Naming Plants

Informant Identification Number									
Avoidance Strategy	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Avoids Abstract Names	Y	Y	Y	Y	Y	Y	Y		Y
Avoids Admitting Ignorance	Y		Y				Y		Y
Avoids Being Wrong	Y	Y	Y	Y	Y		Y	Y	

Previous research (C.H. Brown, 1984; Dougherty, 1979) has demonstrated that in the large-scale technological society of the United States the life form level has become linguistically salient for naming plants. Linguistic salience does not necessarily imply psychological salience, however. Evidence from this study indicated that even when suprageneric names were used frequently, the generic level of abstraction was psychologically basic or preferred for naming plants.

The children used a variety of response types to avoid giving suprageneric names. I believe that children desire to identify objects at the level of abstraction at which they can easily recognize them. They can distinguish between types of trees, therefore they wish to demonstrate that ability. For these children, cognitive knowledge exists but the linguistic knowledge necessary to express that knowledge is often absent.

I have concluded that for eight informants, even if life form names were more frequent, the generic level was psychologically basic or preferred for naming plants.

Informant 8 used a high percentage of suprageneric names and did not seem to rely on strategies to avoid suprageneric names. Concerns about being wrong masked evidence of a preference for generic names. Her use of generic names was low, 37% in the slides, and 25% in the field (Table 5). Nonetheless, generics did make up a significant portion of her responses, indicating that generics were meaningful for her. As did all other informants, she used more generic responses and fewer life form responses in the second slide set. Thus I felt that even for informant 8, generic names were psychologically basic. Her other concerns, however, prevented her from giving generic names for unknown plants.

To avoid using abstract names a student might have to risk an incorrect response (by guessing or making up a generic name) or admit ignorance (by saying, "I don't know"). For all informants, concerns about admitting ignorance and/or concerns about giving a wrong response also seemed to influence their responses. Substituting life form (or other abstract) names would prevent an admission of ignorance and increase the student's chances of being "right." Thus these concerns may have influenced the child to use life form names frequently.

It should be noted that the avoidance techniques described above did not result in names that would be acceptable to a science teacher, but various strategies had the effect of hiding the students' lack of knowledge and preventing a "wrong" answer.

Strategies to avoid being wrong or admitting ignorance may be tools for coping with lack of knowledge and low self-esteem. The research suggests that students are afraid to make errors. To master difficult concepts requires practice. Practice implies that the first few attempts will generate errors (see Fisher & Lipson, 1986). Expression of an inference, although the inference may be wrong, is an aspect of hypothesis testing. Suppression of the expression of error may result in the suppression of creative thinking. Further research is needed on the links between the strategies and student concerns and on the factors that result in those concerns.

<u>Student Performance</u>.

Concerns about admitting ignorance and/or being wrong were manifested in all informants, regardless of sex, ethnicity, and achievement test scores. Achievement test scores may be correlated to some extent with student concerns and student abilities to name plants.

The two students (informants 5 and 6) who displayed the best overall knowledge of plant names were both females with high achievement test scores (refer to Table 1). They also preferred outdoor play. They both had a relatively high percentage of correct generic responses (Table 5). More than 50% of the generic names they used were correct. They were not afraid to admit their ignorance, rarely used made-up names (and acknowledged that those names were made-up), and they used a low percentage of life form names. They were not afraid to guess at a generic name, and even when wrong, their responses often displayed knowledge of related or similar species. These students showed a strong preference for avoiding abstract names for plants and they often volunteered rich descriptions.

The five students (2,3,7,8,9) with less than 20% correct generic names were the students with low to moderate achievement test scores in science (see Table 1). All displayed high levels of concern about admitting ignorance and/or being wrong (Table 12).

In contrast, informants 3 and 9 had the highest number of well-defined categories (discussed in section 1 "Categories for Plants"). Four students with high achievement test scores in science were among the six with poor to moderate level skills in classification of plant categories.

Learning to classify plants is a different type of task than learning names for plants. The skills involved with classification are process skills, whereas learning names for plants is a rote memorization task. The achievement tests may be pointing out the children who excel at rote memorization while overlooking the children who excel at science process skills.

The data suggest that when children lack the information needed to succeed in a task, they are more likely to have a high level of concern about admitting ignorance or being wrong. Is overall school performance also linked to a high level of concern? The five students with low to moderate achievement test scores did have high levels of concern.

Of the five children with overall achievement test scores in the nineties (1,2,4,5,6), four seemed to have less concern about admitting ignorance than other students. But two informants (1 and 4) with high test scores also displayed a high level of concern about being wrong, and informant 1 also displayed a high level of concern about admitting ignorance.

Four students with high test scores rarely used made-up names. Four students with low to moderate test scores in science and low number of correct generic responses (informants 2,3,7,9) used made-up names fairly regularly.

The desire to avoid suprageneric names cut across all demographics. For three informants who performed poorly in naming (2,3,9), avoidance of abstract names outweighed their other concerns.

Types of Errors

Level 1 Assertions

The children's names for plants were often not consistent with the common names acceptable to a botanist. In examining children's names for plants, it was found that certain types of naming errors were common. Some names were inaccurate from a botanical perspective but were commonly used among adult laymen in Texas (e.g., calling a yucca a "cactus"). Frequently, the name the child used was the name of a similar looking species, either botanically related to the specimen or not (e.g., naming a cattail "grass"; naming a sunflower "dandelion"). Some names were invented by the child. These often were descriptive ("thorn plant"). Very rarely did a child think that a plant was a non-plant (e.g., one child thought ball moss was a bird's nest).

The number and types of naming errors made by the children have been summarized in Table 13 (below). All naming errors other than those mentioned above have been lumped together under "undetermined error." Data for each informant have been placed in Appendix A-6. These data were obtained from the domain analysis of strict inclusion (Appendix A-3 includes that analysis for one informant).

Table 13: Numbers and Types of Errors Made by Children in Naming Plants

Informant Identification Number									
Types of Errors	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Undetermined	16	13	7	13	12	12	8	6	5
Layman's Error	8	6	2	3	7	8	1	4	3
Related Species	8	7	3	3	4	7	6	3	7
Similar Form[b]	12	6	0	6	8	10	2	11	5
Made-up Names	6	5	19	2	3	3	15	6	20
Non-plant[a]	0	1	0	0	0	0	0	0	0

Note: a = A plants it thought to be not a plant
b = Not related species

Level 2 Assertions

The students' poor knowledge of generic names for plants was not surprising. Loss of knowledge of names for wild plants seems to be an artifact of our highly technological society. Although most of these informants had names for a few common plants (e.g., prickly pear cactus), few knew names for other common plants such as poison ivy, oaks, and mesquite.

All informants correctly named roses and bluebonnets, most recognized sunflowers, buttercups, Indian paintbrush, and water lilies, but a number did not know names for other common herbs, such as dandelions and clover. Seven identified "cedars" (junipers) correctly, but no one knew the name for bald cypress. And six did not recognize ferns in various forms.

Although sixth grade students gave incorrect names for many common plants, the types of errors made revealed a hidden body of knowledge. While unexplained errors were the most frequent, a large number of naming errors were names of similar looking species (often closely related). These types of errors have been discussed under "overgeneralization," below. From the layman's point of view, some names would not be incorrect (e.g., calling a wood sorrel "clover"). Both of these types of errors indicated a greater familiarity with plant names than did the initial impression based strictly on the percentage of botanically acceptable common names.

I documented cases of overdiscrimination (calling the same species by different names) and overgeneralization (calling different species by the same name) (see Appendices A-7 and A-8). In some studies, overdiscrimination is called underextension or restricted reference, and overgeneralization is called overextension.

Overdiscrimination.

In general the informants had little trouble recognizing the same species in different circumstances. Students could recognize familiar plants in slides or photographs and in unfamiliar settings. All informants overdiscriminated some species, however. Most instances of overdiscrimination involved species that could appear in different forms. For example, seven informants had different names for an agave with and without the large flowering stalk. One informant called the flowering form "wild plant tree" and the non-flowering form "ivery." Another called them "palm tree" and "cactus." When shown photographs of bald cypress with green versus red leaves, several individuals gave the two forms different names: "fern tree" and "pine tree"; "spruce" and "maple."

Sabal palms with and without trunks almost always were designated in different categories, typically, "palm tree" and "cactus." Yuccas with and without trunks also caused difficulty. Several informants did not recognize that the flower stalk on a yucca was actually part of the plant. Spanish oaks with red leaves were commonly called "maples," but only one informant called a maple an "oak."

Several informants had difficulty recognizing trees when they lacked their distinguishing fruits. Pine trees viewed with and without cones might be given different names: "pine" and "spruce"; "pine" and "cedar"; "pine" and "fir." Mesquites, with and without pods; oaks with and without acorns; and bald cypress and junipers with and without cones all might be given different names. The importance of fruit to children's recognition of trees was reflected in the tendency to give all oaks with acorns the same name, but to give different species of oaks without acorns different names. Although most children recognize oaks when bearing acorns, few had correct common names for them. "Acorn tree" was the folk name used by seven informants.

It was quite common for flowering herbs to be placed in different life form categories when with or without flowers. One informant who recognized bluebonnets with flowers, called it "five-leaf clover" without the flowers. Four informants called clovers by different names, even when two specimens had the same flower color. One informant over-discriminated dandelions, and two informants did not know that a dandelion flower and fruit belonged to the same plant.

The two *Tillandsia* species (ball moss and Spanish moss) sometimes received different life form designations, such as "moss and "weed," although most informants called both species "moss," as do many adult laymen.

Overgeneralization.

Overgeneralization of the life forms cactus and grass were discussed in the componential analysis. Certain generic names were overgeneralized by several informants. Most instances of overgeneralization involved closely related species or species that were similar in form. Informants used "clover" more commonly in reference to wood sorrel (*Oxalis*]) than to true clover, but occasionally both species were given that name. I have noticed that this is also a common adult error. "Moss" might be overgeneralized to include a wide variety of odd looking things: lichens, *Tillandsia* species, true moss. These are also common adult errors.

The names dandelion, daisy, or sunflower were overgeneralized by four informants, always in reference to various flowering herbs in the sunflower family. The names "lily pad" or "water lily" were commonly used in reference to three different species of aquatic flowering herbs: true water lily, lotus (both in the same plant family), and water hyacinth (not related, but similar in habit). One informant gave agaves and yuccas (related species) the same generic name, "ivery."

Eight informants (all but informant 3) overgeneralized the conifers. The names "pine," "fir," "spruce," "Christmas tree," and "cedar" might include any two or more species of coniferous trees. Rarely was a non-conifer included but two informants called palm trees "pine." All informants also were able to discriminate between these species, so it did not appear that the generic names had been elevated to intermediate levels in most cases.

"Maple" was overgeneralized by five informants to include Spanish oak, grape vine, sycamore, and/or bald cypress with red leaves. This researcher has noticed that adults commonly will

confuse maples, sycamore, and some oaks, as the deep lobes on the leaves are similar.

Most overgeneralizations may have been the result of a lack of linguistic knowledge rather than a lack of cognitive abilities to distinguish between similar species. Rarely did an informant give two specimens the same name that were not either closely related or very similar in form. Almost all cases in which informants seemed to have problems distinguishing between specimens that were not similar in form occurred at the life form level. For example, informants 4 and 8 called various non-grasses grass, possibly indicating cognitive problems in discriminating small herbs with linear leaves from herbs with broader leaves. For only two of their life form categories (trees and flowers) did these informants have more than three named members. These informants rarely attempted to distinguish between specimens with descriptions. Both used suprageneric names for more than 50% of their responses. Whether these informants really could not distinguish various herbs or whether they simply were not interested in doing so is a question of interest for later study.

Level 3 Assertions

Most instances of overdiscrimination involved species that could appear in different forms. Most cases of overgeneralization involved related or similar looking species. Macnamara (1982) commented that perceived similarities are commonly the basis of overextensions.

Stross (1973) found that by age 12, children in Mayan Mexico rarely made errors of overgeneralization or overdiscrimination. Clearly, at that age children are capable of differentiating between specimens that are similar in form. The fact that the children in the United States often did not do so indicates either that they were not aware of distinguishing characteristics and/or they were aware of the differences but lacked knowledge of the names for plants. I feel that both problems contributed to naming errors.

In this study, overdiscriminations were found to be more frequent than overgeneralizations. Kendler and Guenther (1980) also found overdiscrimination to be more common than overgeneralization in older children (ages 5-8). Macnamara (1982) stated that overgeneralizations are less common because of a desire to avoid being wrong, which results in caution in naming things. When overdiscriminating, the individual is less likely to be wrong than if he overgeneralizes.

From his research with preschool age children, Anglin (1977) has concluded that the most important factor in underextension and overextension is the object's similarity to the typical member of a class. If a plant species, for example, resembles the prototype of another species, the individual infers that it is the same species (resulting in overgeneralization). If a specimen differs from the prototypical specimen of the same species, the individual infers that it is not the same species (resulting in overdiscrimination).

In the current study, overdiscrimination of some species (e.g., pines) indicated that the child was attending to just one attribute, the fruit, the flowers, or the leaves. Kendler and Guenther (1980)

pointed out that in overgeneralizing as well, the child often relies on a narrow range of attributes for classification. These children may not have had enough experiences examining wild plants to attend to a variety of attributes. The common use of monothetic criteria in classifying major plant categories attests to this (refer to the section "Categories for Plants" for discussion).

Macnamara (1982) has suggested that a factor that has not been properly examined is "the possibility of a sense of metaphor as opposed to the types of confusion that the word overextension suggests" (p. 50). The child who calls a sunflower "dandelion" may mean that the specimen "looks like a dandelion," not that it is a dandelion.

This researcher believes that when an individual presents a name for a plant, he or she is making an educated guess based on the observable data and the student's knowledge base. For example, red leaves that have deep lobes can grow on both oak and maple trees. The children in this study commonly called both trees "maple," indicating a lack of knowledge of differences between palmately lobed and pinnately lobed leaves. Thus, the student's inference is made from a limited but not a naive knowledge base.

The current study provided evidence that metaphor was also a factor in overgeneralizations. The fact that several members of the sunflower family were called by the same name, despite easily detected differences (such as flower color) suggests that the informant was simply noticing all as being "like a sunflower."

All informants displayed remarkable abilities to recognize different species as belonging to one family. The members of some of those botanical families take on quite different forms. Through their overgeneralizations, all informants revealed abilities to recognize similarities between species of at least four of the following botanical groups: the class of conifers, the sunflower family, the cactus family, the water lily family, and the grass family. And although no one used the name "lichens," six informants placed two very distinct lichens in the same category (typically calling them both "moss," "fungus," or "algae").

Rather than an indication of an inability to discriminate between similar species, overgeneralization may often indicate an ability to recognize family relationships. The children seemed to prefer substituting an erroneous generic name, if it reflected their cognitive abilities to differentiate between specimens, to using a suprageneric (more abstract) name.

Overdiscrimination of life forms (e.g., grass) may sometimes be the result of overlap between categories. The child may have known that various specimens were all grasses, but he may also have thought of them as being plants or weeds, thus not all specimens of grass were placed in the category grass. Further study is needed on overdiscrimination of life form categories (refer to the section "Categories for Plants" for further information on overdiscrimination of life form categories).

Both overdiscrimination and overgeneralization are artifacts of learning language. They are not necessarily either bad or good. They probably are necessary aspects of learning language, of

learning how to classify. The young child may call only the cat that lives in her house "kitty" at first (overdiscrimination). At some point she may call both dogs and cats "kitty" (overgeneralization). If normal linguistic development occurs, one would expect her eventually to use the term "kitty" only for a wide range of types of cats.

For the children in this study, overgeneralization and overdiscrimination remained common at a late age due to the lack of familiarity with the particular types of objects examined, wild plants. Due to diminished reliance on wild plants for food and other useful products, children have little need to know names for these plants. Unless an interest develops later in life, they may never overcome their overdiscriminations and overgeneralizations. But these types of "misconceptions" are unimportant from the point of view of the adult layman (who probably shares them). It is not useful to be able to distinguish between a pine and a fir - either is suitable for a Christmas tree. Overdiscrimination and overgeneralization are often relative to the context. Texans have just one name for snow. To the Alaskan, such a designation would be considered a gross overgeneralization.

<div align="center">Names for Plants: Summary</div>

Comparison with Other Studies

Refer to Chapter II, "Names for Plants" for a summary of similar studies conducted with children in Mexico (Stross, 1973) and California (Dougherty, 1979). A few additional trends found in other studies have been added here as a point of comparison.

Stross found that, when they did not know generic names for plants, his younger children (age 4) would substitute a suprageneric name or make up a name rather than say, "I don't know." Older children (age 9 and older), particularly boys, were more likely to say, "I don't know," or give no response than to make up a name or use a suprageneric name.

Stross' informants used many of the same response types as were found in this study. For example, informants would sometimes describe the use of a plant when they could not remember the name, and they frequently added descriptions or information on use when naming plants. Thus these children also used various strategies that resulted in avoidance of abstract names.

Dougherty (1979) has attempted to put together a developmental scheme for how children name plants. Data from the current research suggest that differences between responses given by Dougherty's informants were idiosyncratic rather than developmental. Remarkable similarities occurred between the types of responses given by children in both studies (e.g., polysemous use of the category plants, similar errors of overgeneralization and overdiscrimination, similar names for life form categories).

Data from the current study with 12 year olds suggest that the poor performance of the older children in Dougherty's study may not improve as the child progresses through the educational system. The similarity of the children's responses in the two studies provided evidence that the

mistakes children make in classifying plants are likely to be wide-spread in American culture.

This researcher would agree with Dougherty that overgeneralizations may play an important part in cognitive development. In rural Mexico, Stross (1973) found that children's errors in naming decreased with age. It may simply be that, for children in the United States, what should have been an early stage of a developmental sequence (numerous errors of over- and underextension in naming plants) has become the end product. More research is welcomed in this area.

In other studies with children (Stross, 1973; Dougherty, 1979) made-up names for plants were also found to be descriptive in nature. Berlin (1972) has suggested that plant names often expand from single words (generic names) by the addition of descriptive phrases which eventually become an accepted part of the name (e.g., red oak, poison sumac). In this study, the made-up names were often derived from life form names ("thorn tree," "acorn tree").

Summary of Level 2 and 3 Assertions

In urban settings, even when the life form level has become linguistically salient for naming plants, the generic level remains psychologically basic. Students' concerns about admitting ignorance and being wrong affected their responses when they did not know the generic names for plants. The result may be an increased reliance on suprageneric names.

Children remember best the names for plants with human applications. The children in this study lacked knowledge of names for many common wild plants but the types of errors indicated a greater knowledge base than the number of errors alone implied. Some common names would be acceptable to the adult layman although not to a botanist. Most errors of overdiscrimination involved species that can appear in different forms. Children had difficulty recognizing some plants when a single salient characteristic was missing (fruit, flowers, leaves). Most errors of overgeneralization involved closely related or similar looking species.

Section 4: Textbook Concepts Compared with the Conceptions of the Child

Introduction

A textbook review was conducted to evaluate how botanical concepts were presented in the elementary textbook series *Silver Burdett Science*. A brief review of the seventh grade textbook Macmillan *Life Science* was also made.

The textbook review has been divided into three main areas of concern: the language used in the text, the development of botanical concepts in the text, and the pedagogical emphasis of the text. The children's interpretations of botanical phenomena have been compared with the interpretations found in the elementary text. As a result of that comparison, recommendations have been made for textbook revisions.

In the initial scan of the botanical propositions from grades one through six, a number of patterns and inconsistencies were noted. Some statements in the text were found to be inaccurate or misleading. Numerous scientific concepts seemed to be undefined by the text. Many common names for plants referred to plants that do not grow in central Texas. A large number of propositions referred to abstract concepts - concepts lacking a tangible referent. Little information was included on human uses of plants and other topics with relevance to the daily life of the child. A number of botanical concepts were repeated in several grades. These aspects of the text were documented in detail.

In Appendix B-1, the botanical propositions found in the text, grades one through six, including the codes indicating which propositions were judged to be abstract or concrete. Appendix B-2 lists the names for plants found in the elementary text, indicating which were judged to be unfamiliar to students in central Texas. Appendix B-3 lists the terms for botanical concepts found in the elementary text, indicating which were judged to be scientific terms. The researcher developed concept maps of the botanical propositions (Appendix B-4). Appendix B-5 provides a summary of the false and misleading statements found in the elementary texts. Appendix B-6 lists the topics that were repeated in more than one grade (grades 1-7). Appendix B-7 provides a summary of the botanical topics covered in grade 7, with redundant material indicated. These lists provided the basis for the textbook review.

The Language of the Text

Textbook Names for Plants: Level 1 Assertions

Text. The textbook introduced many common names for plants (refer to Appendix B-2). Some plants were illustrated and some were not. In grades 4-6, 27-40 % of the plants referred to in the texts do not grow in central Texas (see Table 14). For example, most examples of conifers, evergreens, and deciduous trees, were of plants that do not grow in central Texas. Of the more than 100 species of cactus that grow in the United States, only two (saguaro and prickly pear) were included in the text. Saguaro does not grow in Texas. The text did not depict the diversity of forms found in the cactus family.

I assumed that plants that do not grow in central Texas (or are not commonly sold in groceries) would be unfamiliar to the children in this study. Table 14 (below) lists the percentage of plant names used in each grade that would be unfamiliar to children in central Texas.

Children. The interviews revealed that the children in this study generally were able to identify plants viewed in the field as being the same as they had seen in the slides. The children had very few accurate names for those plants, however (refer to the section "Names for Plants"). The children knew names for some plants (e.g., maple, oak) that they could not identify in the field or in slides. In other words, they had knowledge of names for plants but did not know how to match the names to the appropriate objects.

Table 14: Percentage of Unfamiliar Plant Names in the Elementary textbook series, <u>Silver Burdett</u> <u>Science</u>

Grade	Ratio	Percentage
1	2/10	20
2	1/17	6
3	9/91	10
4	29/72	40
5	8/24	33
6	14/51	27

Textbook Names for Plants: Level 2 Assertions and Recommendations for Educators

The text used a high percentage of names for plants that do not grow in the child's environment. I have suggested that the use of unfamiliar plants has the effect of placing the concrete in the realm of the abstract.

Research is needed to determine the effects of teaching botanical concepts with local plants as the exemplars. Guided field experiences with familiar plants may be a valuable tool for the elimination of many misconceptions related to plant categories (discussed below).

For example, several children in this study had the misconception that all conifers are evergreen. That concept may be easy to dispel if the child is shown the conifer, bald cypress, in the winter. The misconception that all broadleaf trees are deciduous may be dispelled by showing the child a number of broadleaf evergreen trees in the winter.

Textbooks produced for nationwide use cannot be expected to provide sufficient examples of plants from all regions of the country. Regional supplements may be a necessity for effectively teaching botany. Teachers can compensate for a non-regional text by introducing students to plenty of local plant material, both in photographs and in the field. Regional field guides are valuable resources for teachers and students.

An occasional story about an unfamiliar but interesting plant, such as the Venus fly trap (a plant name which several informants recalled), may be useful for discussions of topics such as unusual plant adaptations.

The current research demonstrated that children can recognize familiar plants in slides. Thus slides and photographs can be useful tools for classroom instruction. Plants the teacher considers familiar may not be familiar to the child, thus photographs should be used as a supplement to field experiences and not as a substitute for it.

<u>Terms for Botanical Concepts</u>

<u>Level 1 Assertions.</u>

<u>Text</u>. As mentioned in the literature review, Meyer et al. (1988) found that *Silver Burdett Science* introduced a large number of science vocabulary in every grade. In this study, the botany related terms were documented for grades one through six. In Appendix B-3 the newly introduced scientific terms have been marked with an asterisk. I classified as "scientific" any term that is not commonly used in the adult vernacular. For example, <u>tree</u> was classified as a folk term but <u>monocot</u> was classified as a scientific term. Table 15 (below) has listed the number of scientific botanical terms newly introduced in each grade.

<u>Level 2 Assertions and Recommendations for Educators.</u>

The text used numerous botanical terms that would be unfamiliar to children. In *Project 2061*, the AAAS (1989) stated that much of the scientific terminology in textbooks is not essential to the learning of science concepts. I question the value of using terms such as monocot, dicot, ovule, and vacuole in elementary school science.

***Table 15: Number of Scientific Terms Newly Introduced in Each Grade of the Elementary Textbook Series,* <u>Silver</u> <u>Burdett</u> <u>Science</u>**

Grade	Number
1	0
2	3
3	14
4	21
5	31
6	33

What is the textbook emphasis on vocabulary telling our teachers and students about what is important to learn in science? Judging by the textbook, it appears that science vocabulary has become more important than concept development.

<u>Vocabulary Definitions</u>

<u>Level 1 Assertions.</u>

<u>Text</u>. Of the 156 botany related terms introduced in the elementary science textbooks (both folk and scientific terms), only 54% were explicitly defined by the text (see Appendix B-3). Table 16 (below) has listed the percentage of botanical terms that were not explicitly defined in each grade.

Of the 85 terms that were explicitly defined in the text, 39 were discussed in one passage of one

text, with no examples or with so few examples that the novice could not be expected to grasp their meaning. For example, the terms niche and ecology were represented by few or no examples. And some terms (e.g., mitosis, vacuoles, ovary) were used once in the text, only in the context of their definitions.

46% of all botanical terms were not defined in any grade (71/156). Of the 71 botanical terms that were not explicitly defined, eleven were represented by visual illustration alone (acorn, bloom, forest, leaflets, compound, simple, toothed, lobed, limb, sprout, bush), and 15 were neither illustrated nor defined (bark, bud, chemicals, conduct, conserving, dispersed, gravity, hydrogen, interactions, nuts, surface area, transported, waste materials, wood, wildflowers). The remaining 45 were represented by some type of verbal and/or visual information, but that information was inadequate for defining the term.

Table 16: Number and Percentage of Botanical Terms Not Defined in the Elementary Textbook Series, Silver Burdett Science

Grade	Ratio (undefined botanical terms/total botanical terms)	Percentage undefined
1	11/13	85
2	13/16	81
3	31/48	65
4	35/55	64
5	27/60	45
6	53/85	62

Level 2 Assertions and Recommendations for Educators.

The textbook authors seemed to assume that some vocabulary did not need to be defined. They also seemed to assume that explicit definitions would be adequate to enable the reader to grasp the meanings of vocabulary. Both assumptions are called into question.

Leo Tolstoy (Vygotsky, 1962) suggested that it may be useless to give a child a new concept in a deliberate, artificial explanation. The child must hear or see the word in linguistic context. Explicit definitions alone may not be adequate to convey meaning. Many concepts in the text were not illustrated with enough visual or verbal examples to enable the reader to recognize the concept in its diverse forms.

The interviews confirmed that the children in this study often did not have meanings for terms that would be comparable to those of a botanist (for discussion, refer to section "Categories for Plants," above, and the discussion of concepts below). Students had misconceptions about terms

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for concepts with concrete referents (e.g., leaf, petal, bud, bloom) and terms for abstract concepts that were explicitly defined in the text (e.g., photosynthesis, reproduction).

I suggest that to assist children in comprehending new scientific terminology, the text must go beyond a verbal definition. The concept must be illustrated visually and/or with diverse concrete verbal examples if the student is to fully grasp its meaning.

For some highly abstract concepts, such as photosynthesis, there are no appropriate concrete referents. As presented in the text, these concepts seemed to be too abstract for the children. Concepts with concrete references, such as pistils and stamens, will probably remain abstract to the child unless the child is given opportunities to examine exemplars of the concept in diverse forms on real plants.

Concept Development

I drew concept maps of the botanical propositions included in the elementary textbooks grades one through six (see Appendix B-4). The maps were used to evaluate the development of the botanical concepts in the text, the complexity of the text, and the connections made between interrelated concepts.

Connections between Concepts

Level 1 Assertions.

Text. The text generally provided enough information to allow mental connections between the various concepts presented. For example in grade four, the scientific classification scheme was reasonably well presented, with connections made between the various levels in the hierarchy. In grade five, the processes of photosynthesis and respiration were reasonably well explained and interconnected.

The maps revealed gaps in the text between some interrelated concepts. In grade 1 flowers were not connected to plants. In grade 2 trees were not connected to plants verbally, though they were pictorially. In grades 4 and 5, the relationship between plants and green plants was not explained. In grade 6 trees were not connected to plants. In grade 3, the text discussed the importance of food for the body but no mention was made that we get food from plants.

Children. The data from the student interviews indicate that the students had misconceptions or lacked knowledge of the relationships between various concepts that were presented in the text. For example, three informants did not know that trees are types of plants. Several students did not understand the relationship between leaves and food production and between flowers and reproduction. The informants did know that food comes from plants. The students' conceptions have been detailed below, with the information on textbook development of concrete and abstract concepts.

<u>Level 2 Assertions and Recommendations for Educators.</u>

Without the benefit of a visual guide, such as concept maps, some elementary students may not be able to make explicit the interrelationships between concepts that are implicit (or not present) in the text. Connections between concepts may need to be made explicit in the text.

Concept maps may be useful tools for assisting children in comprehending relationships between concepts. If children develop their own concept maps of the science concepts presented in the text, will those maps enable the students to make the necessary connections between concepts? This is a question for teachers to explore. If connections are not present within the text, concept mapping will not assist the child in comprehending the concepts. Teachers can use the concept maps drawn by the child to discover the areas in which the child has not made connections between concepts, and the teacher can draw her or his own concept maps to evaluate what concepts are not adequately explained and connected in the text.

<u>Levels of Complexity</u>

<u>Level 1 Assertions.</u>

<u>Text</u>. The concept maps revealed the complexity of the material presented at each grade level (Appendix B-4). In grades 1 and 2 the maps included from two to five hierarchical levels. In grades 3 to 6, three to six levels were common and several concepts had seven to ten hierarchical levels. In grades four through six, the maps become increasingly complex, with many interconnecting lines between major concepts.

<u>Children</u>. A concept mapping exercise was conducted with the nine children. The students typically used two to five hierarchical levels per major concept (see Appendix C-5). Only one informant (# 6) used more than five levels. She used up to seven hierarchical levels for some concepts.

<u>Level 2 Assertions and Recommendations for Educators.</u>

The textbook authors seemed to assume that elementary students can learn scientific concepts presented with a complex hierarchical structure. Examination of the informants' concept maps suggests that these students can best handle concepts with two to five hierarchical levels. The concept mapping exercise was exploratory and was not conducted in a systematic manner, so further research is needed to ascertain the viability of this assertion. As mentioned in the literature review, Staver and Bay (1989) question whether or not textbooks are overloading the young students' working memory capacities. Elementary students may have trouble piecing together the complex hierarchical relationships implicit in the textbooks.

Questions for further study would include: When introducing scientific concepts, how may levels of complexity are appropriate for children? How many levels of complexity can the child deal with

when talking about familiar versus unfamiliar topics? Student drawn concept maps may be valuable tools for such study.

False and Misleading Statements

Level 1 Assertions.

Text. A number of false or misleading statements were found in the elementary textbooks. Refer to Appendix B-5 for an annotated list. The appendix has included some comparison of concepts as presented by the textbook and by the children.

For some terms used in the text, the folk meaning differs from the scientific (botanical) meaning. For example, fruit has different meanings depending on whether one is speaking of food or reproduction. Herb has both a culinary and a botanical meaning. The text generally failed to differentiate between the botanical meaning and the folk meaning of a term. Thus the text tended to perpetuate misconceptions about botanical meanings.

Children. Some textbook errors were also stated by the informants. For example, in grade five in a section on plant and animal interactions in an aquarium, the text stated, "Without the fish, the plants would die. Without the plants, the fish would die." Several informants stated that plants cannot live without the carbon dioxide produced by animals. These students may have learned this misconception from the text.

Level 2 Assertions and Recommendations for Educators.

Some student misconceptions may be the result of false and misleading statements in the text. That students repeated errors found in the text may indicate that they were, at least, learning from the textbooks.

The number of false and misleading statements found in the text was alarming. This calls into question the editorial policies of the publisher. The publisher apparently did not have the text reviewed by scientists in each science area.

Surprisingly, Meyer et al. (1988) found no false statements in their review of 57 chapters of textbooks from four publishers, including Silver Burdett. Why was there a discrepancy between their discoveries and those of the current analysis? Perhaps these divergent results indicate the inadequacy of sampling from the whole text. In depth study of a narrow range of information, as was done here with botany concepts, may be better suited to some aspects of textbook analysis.

Repetition of Botanical Topics

Level 1 Assertions.

<u>Text</u>. A number of major and trivial topics were repeated in two or more grades. For example, community was defined explicitly in grades four and five. Germination is discussed in grades 3,5,6, and 7. The function of roots and stems is repeated in grades 3,5, and 7.

In discussing adaptations, the text repeated some examples in more than one grade. For example, the idea that needles are adaptations to conserve water was repeated in grades four and six. Cacti were also used as examples for explaining water conservation in grades four and six.

For a list of the concepts repeated in grades one through seven refer to Appendix B-6. Appendix B-7 lists the major botanical topics covered in the seventh grade text *Life Science*, with an indication of which topics were also covered in the elementary science texts. Fifty to sixty percent of the botanical material in the seventh grade life science text was redundant. A number of propositions (e.g., "living things are made up of cells") and topics (e.g., explanations of the environmental needs of plants) were repeated in three or more grades.

<u>Children</u>. Children's conceptions of various concrete and abstract concepts have been discussed in detail below. The children in this study displayed a poor understanding of several of the concepts that were repeated in several grades (reproduction, photosynthesis, needs of plants).

<u>Level 2 Assertions and Recommendations for Educators.</u>

The interviews with the children indicate that repetition of abstract concepts does not guarantee increased comprehension. Repetition of trivial information probably results in a boring text.

Some repetition is warranted. For example, if the student is expected to grasp the meaning of scientific vocabulary, terms need to be repeated in a variety of contexts. The repetition found in the textbooks tended to be of a different nature, however. Some trivial propositions were repeated unnecessarily (e.g., the idea that plants change seasonally was repeated in grades 2,4, and 6). Some important concepts were explained in a redundant manner from grade to grade. For example, the term photosynthesis was mentioned in context only once, in grade 5, but the idea that plants make their own food was presented in grades 3,4,5,6, and 7. The idea that plants produce seeds that grow into new plants was repeated in grades 1,2,3,6, and 7.

If a concept is worth repeating, diverse examples of the concept should be used in each case. The textbook failed to do this with numerous concepts. For example, the text used the saguaro as an example of cactus in every grade. The text could acquaint students with the various forms of cacti by using a variety of species in each grade.

Trivial science facts (such as the proposition, "plants change seasonally," and "seeds have different shapes and sizes") and highly abstract concepts (such as photosynthesis and the life processes) that are repeated year after year could have been explained once in a simple, allegorical manner, or left out of the elementary textbooks altogether.

In *project 2061,* the AAAS (1989) recommends, "To ensure scientific literacy of all students, curricula must be changed to reduce the sheer amount of material covered" (p. 5). "The schools do not need to be asked to teach more and more content, but to teach less in order to teach it better" (p. 20). The textbook analysis has revealed that the amount of material covered in the elementary grades can be significantly reduced by omitting redundant information.

Textbook Development of Concrete Concepts Compared to Student Conceptions

Plant Names and Categories

Level 1 Assertions.

Text. The textbook presented erroneous information about some plant categories. For example, the text called fungi a type of plant, which is an outdated classification. The text perpetuated the myth that all evergreens are coniferous. The discussion of classification schemes, below, has included more information on plant categories. Also refer to Appendix B-5 (false and misleading statements) for information on textbook use and misuse of categories.

Problems with using names for unfamiliar plants has been discussed above in the section "The Language of the Text."

Children. Information on the children's names has been discussed in section 3, "Names for Plants." Detailed information on the students' categories for plants was covered in section 1.

Plant Parts: **Level 1 Assertions**

Flowers: Text. Most visual examples of flowers in the textbook were growing on herbs, thus the textbook tended to promote the misconception that flowers grow only on herbaceous plants.

Although the statement that "some plants produce flowers" was repeated in grades 2,3,4, and 5, the names for the reproductive parts of a flower were not introduced until grades 4 and 5. The following flower parts were defined in the text: petal, stamen, pistil, ovary, ovule, pollen grains. Few illustrations were used despite the fact that reproductive flower parts are highly variable in nature.

Children. The children in this study used flowers mainly in reference to herbaceous plants. A few expressed the misconception that flowers do not grow on trees. One informant who was making a flower collection for school did not want to collect flowers from trees because the teacher's only examples had been of herbaceous plants. She was concerned that the teacher would not consider flowers from trees to be "real flowers."

Although all the children in the study could recognize accurately most examples of flowers and

leaves, two children also called colorful leaves <u>flowers</u> on at least one occasion. Three individuals called some fruits <u>flowers</u>. Although seven informants used the term <u>petal</u> accurately in at least one instance, in the field seven informants occasionally called petals <u>leaves</u>.

At least seven informants were familiar with the term <u>pollen</u> and could recognize some examples but no one had any idea of its function. Although several informants pointed out the stamens and pistils when describing flowers, only informant 6 used the term <u>stamen</u> and no one used the term <u>pistil</u>. Five informants filled out a multiple choice questionnaire in which they were asked to pick out the names for the parts of a flower. Three did not select <u>stamens</u> (<u>pistils</u> was not one of the selections) and one (informant 7) did not select <u>petals</u>.

   <u>Bud, seed, fruit, and berry</u>: Text. The structure and function of <u>buds</u> was not mentioned in the text and the term was used only once, in grade four. <u>Bloom</u> was not defined and was rarely used in the text. <u>Berry</u> was never used in the text.

In both grades 2 and 3 the textbook accurately stated that the inside of a flower changes into a fruit and that seeds form inside the fruit. The textbook defined <u>seed</u> and <u>fruit</u> accurately. <u>Seed</u> was used in the text frequently, but <u>fruit</u> was used infrequently. Both concepts were accurately illustrated in several grades. In grade 2, however, the text used <u>fruit</u> in reference to edible, fleshy fruits. And in grades 2 and 6, dry fruits were mistakenly labeled <u>seeds</u>. The text did not differentiate between culinary and botanical meanings for <u>fruit</u>. By its use of illustration, the textbook promoted the myth that all botanical fruits are fleshy and edible.

   <u>Children</u>. Labels such as <u>bud</u>, <u>seed</u>, <u>fruit</u>, and <u>berry</u> were frequently confused by the children in this study. The informants did not consistently differentiate between these objects. In nature all of these structures vary considerably in shape. Some buds are round and resemble some berries, and some fruits are dry and resemble some seeds.

At least six informants knew that before it opens, a flower is enclosed in a bud. Some informants called opened flowers or small round fruits or seeds <u>buds</u>, and some did not know that leaves can also be enclosed in buds. Two informants used <u>bloom</u> inaccurately in reference to buds or germinating seeds. Informant 3 said that before a leaf opens it is a seed. Informant 2 believed that buds are attached to some herbaceous plants but not to trees and that berries are the equivalent structures on trees.

Although at least seven informants could correctly identify some berries, several did not know that seeds are inside berries. Most informants knew that when a seed is buried in the ground a new plant will grow out of it. But no one knew how a seed is formed and some believed that seeds appear on trees but that flowers do not.

The informants rarely used the label <u>fruit</u> for fruits seen in the field. They used the label almost exclusively for fleshy, edible fruits such as apples. Virtually any type of dry fruit was called a seed. I have noted that this is a common use of the term <u>seed</u> among adult laymen.

Leaves: Text. The textbook adequately defined leaves and veins. A variety of leaves from broadleaf trees and needle-bearing trees illustrated the concept leaf. Atypical leaf types (such as on yuccas) were not illustrated.

Children. All informants recognized most examples of leaves. At least two individuals did not recognize atypical leaf forms such as on agaves and yuccas, and some informants did not consider blades of grass to be leaves. Some called the fruiting heads on grasses and the stems of prickly pear cacti leaves. Seven informants occasionally called flower petals leaves. At least six informants accurately used the term veins in reference to parts of leaves.

Other plant parts: Text. Trunk was adequately defined in grade 3. The first grade text called tree trunks stems, which is botanically accurate. It was surprising that the text did not also call them trunks. The text did not adequately define the concepts bark, branches, and limb.

Children. Most informants used the terms branches, trunk, limbs, bark, and cones accurately. Two individuals called the woody part of a tree the stem and did not use the term trunk. The fact that the students generally used the terms accurately indicated that the lay usage of the terms may be common enough for the students to pick up their meanings outside of the text.

Plant Parts: Level 2 Assertions and Recommendations for Educators

In grade three, the objectives for mainstreaming included that the child be able to identify roots, stems, leaves, flowers, and seeds and explain their function. Information on these plant parts was repeated in several grades. And yet the six grade students in this research displayed misconceptions concerning these plant parts and had little knowledge of their function.

Previous research has demonstrated that students have misconceptions about abstract botanical concepts, but I was surprised by the number of misconceptions related to concrete concepts. Though some misconceptions related to concrete botanical concepts may alter as the individual matures, anecdotal field evidence has demonstrated to this researcher that confusion about some concepts (such as leaf, flower, petal) can linger into adulthood.

The text did not provide enough visual illustrations to enable the child to recognize flowers and leaves in a variety of forms. Most misconceptions related to plant parts may be due to the similarity in form of some of these structures (e.g., buds and berries). Other misconceptions were likely due to lack of guided observations (including microscope study) that would enable the child to learn to differentiate between similar looking forms.

I believe that many problems children have in identifying plants, categories, and plant parts can be readily illuminated with guided field experiences and classroom discussion of the child's inferences. Research is needed to verify this assertion.

The fact that so many misconceptions occur with concepts defined by the text (e.g., leaf, flower,

fruit) supports the assertion that verbal definitions are not sufficient to impart understanding. Textbooks do not have room for enough illustrations to demonstrate the great diversity in life forms of plants and plant parts. Regional supplements, slides and photographs, and outdoor field experiences may be necessities if teachers want children to learn botanical concepts. Students need many opportunities in elementary years to explore the natural world in a guided manner, making and recording observations.

In a pilot study (Tull, 1986), this researcher interviewed five children from ages five to nine in an outdoor setting. Several children gave detailed descriptions of flowers, pointing out the pistils and stamens, although that they lacked names for these parts. As young children are capable of describing the parts of a flower, I expect that they are also capable of learning the labels for those parts. The textbook could introduce labels for the parts of a flower in the lower elementary grades. The functions of these parts do not need to be discussed until later years or when the child introduces the question of function him or herself.

Textbook Development of Abstract Concepts Compared to Student Conceptions

Preponderance of Abstract Concepts in Text

Level 1 Assertions.

Text. Appendix B-1 has listed all the botanical propositions in grades one through six. Three different coders judged the propositions, thus each proposition has three letters in front of it. "C" designates a concrete proposition, "A" designates an abstract proposition, and "A/C" indicates that the proposition was judged by that individual to be both abstract and concrete. For example, the proposition, "Many plants are used for food," was judged to be concrete by all three scorers. The proposition, "Green plants make food by the process of photosynthesis," was judged to be abstract. The proposition, "Mosses and other tiny plants called lichens weather rock by chemical action," was judged to be abstract by two coders but the third said it was partly abstract and partly concrete.

Because agreement between coders was high (79% and 81%), the percentage of abstract versus concrete propositions was determined from the researcher's coding alone. The percentage of abstract botanical propositions covered in the elementary textbooks was a significant portion of the total text ranging from 17% in first grade to 79% in sixth grade. Table 17 (below) lists the percentage of abstract propositions in each elementary text.

The concept maps developed by this researcher were used to evaluate how each concept was developed in the text (Appendix B-4). Below, some of the major botanical concepts have been discussed. Comparisons have been made between the textbook treatment and the students' conceptions of specific concepts. Findings of related studies have also been included where appropriate.

Children. The interviews revealed that the informants had a very poor understanding of the abstract concepts found in the text, even though some of the concepts (photosynthesis, for example) were repeated year after year.

Level 2 Assertions.

The textbooks apparently did not succeed in presenting abstract concepts in a manner that elementary children could comprehend. Clearly, we are inundating our elementary students with an unwarranted amount of material not applicable to their level of cognitive development.

Table 17: Number and Percentage of Abstract Botanical Propositions in the Elementary Textbook Series, Silver Burdett Science

Grade	Ratio (abstract/total botanical propositions)	Percentage
1	5/30	17
2	13/61	21
3	40/117	34
4	59/117	50
5	149/196	76
6	135/170	79

Differences between Living and Non-living, Plant and Animal: Level 1 Assertions

Text. In grades five and six the text stated that living things are made up of cells, and that living things need energy to carry out the life processes. The text repeated various concepts related to cells in grades 5 and 6. The sixth grade text described the parts and functions of the cell in some detail.

Activities of living things ("life processes") were presented in all grades, in droning repetition: living things can grow, respond to the world around them, reproduce, use energy, get food, and remove wastes. Lacking a variety of concrete examples, most of these activities were presented in an abstract manner.

The first grade text stated that living things grow, change, produce living things of the same kind, and many can move on their own. To stay alive, living things need food, air, water, and a place to live. Nonliving things do not grow or move on their own.

In several grades, the text stated that plants and animals are both living things. In grade four, the text differentiated between animals as consumers of food and plants as producers of their own food.

The text did not challenge the misconception, common among young children (see Piaget, 1929), that anything that moves is living. In grade 1 chapter 5, the statement, "Many living things move

on their own," accompanied a photograph of animals running and flying by the ocean. The juxtaposition could promote the inference that the ocean is living.

Children. In the field interviews I asked how the informant distinguishes between plants and animals and between living and non-living things. Although all informants knew that plants are living things, five stated movement as the main criterion for distinguishing living from non-living. All informants listed movement as an important criterion for distinguishing animals from plants.

At least one informant (informant 2) believed that water is living because it moves. Except when referring to specific examples (e.g., comparing trees to horses, or trees to rocks), most informants had trouble stating differences between plants and animals or living and non-living things other than movement. A few students reiterated text-taught terminology (such as "gets energy, responds, reproduces"), but their answers revealed misconceptions about those concepts. Only informant 1 mentioned cells as a characteristic of living things.

I did not ask questions about cells. Only two other informants, 7 and 9, referred to cells at all. Both revealed lack of knowledge of the function of cells, although they recalled some vocabulary related to the parts of a cell.

Here is a sample of two dialogs concerning living things:

Researcher: "What are the different kinds of living things?"

Informant 1: "Everything that has the four life processes is living. And everything that doesn't, isn't."

R: "So all the plants are living?"

1: "Pretty much."

....

Informant 9: "If it moves it's living, or, well, sometimes moves. Like something that's non-living, I can't explain, but it's just not living. Like these rocks are not living."

Researcher: "How can you tell?"

Informant 9: "Because it doesn't have any life inside."

Additional studies. Other research has also shown that children have difficulty defining differences between living and non-living. In a study in Israel (Tamir et al., 1981), 424 children in grades 3-9 were asked to classify various objects as living and non-living. 99% of the students recognized all the animals as living. Eighteen percent did not recognize all the plants as living and

20% classified various inanimate objects (e.g., fire, river, air) as living. No statistically significant differences were found between age groups. It was also found that many of the students considered life in animals as being different from the life in plants or in inanimate objects. Movement was the most common criterion named for determining whether or not animals and inanimate objects were alive. Growth and development was the most common criterion named for determining that plants were alive.

In a study in England (Brumby, 1982), university biology students were asked questions about distinguishing living from dead and non-living objects. Movement was the criterion named most often for determining whether something was alive. Other criteria indicated rote memorization of text-taught information (respires, eats, grows, reproduces, excretes wastes). Only seven of 52 students mentioned cells as a characteristic of living things. When asked how to determine whether something was not alive, the most common responses were absence of cells and absence of organic chemicals. The students exhibited confusion about criteria for distinguishing dead from non-living.

Marek (1986) found that only 16% of 60 high school biology students had a sound understanding of the cell. In a study of students in Israel, Dreyfus and Jungwirth (1988) found that most tenth grade students lacked knowledge of the functions of cells (they had studied cells in ninth grade). Dreyfus and Jungwirth have concluded that cell theory is too abstract for ninth grade students.

Differences between Living and Non-living, Plant and Animal: Level 2 Assertions and Recommendations for Educators

This researcher feels that the text-taught criteria for living versus non-living may be too abstract for elementary students. Other than movement, the concepts "grows, responds, reproduces" are intangible and vague. Concepts related to the parts and functions of cells may be too abstract for elementary or even middle school students. Teachers are probably not aware that the concepts plants and animals and living can seem very abstract to children.

Research is needed that would demonstrate what techniques would be appropriate for teaching these concepts to children. Can open discussion of students' conceptions help students to recognize limitations in their ideas? Can these concepts be made less abstract through experiential science (e.g., field and laboratory observations of growth and response types in plants)?

Will comparison and contrast between living and non-living objects and between plants and animals (in field and laboratory) assist students to (1) become aware of the limitation of "movement" as a sole criterion for differentiation and (2) use more reliable criteria, such as presence of roots, stems, and leaves on seed plants and presence of cells in living things?

The idea that "cells are the building blocks of life" may be appropriate for fifth or sixth grade science if the proposition is accompanied with numerous opportunities to examine cells under a microscope.

Reproduction: Level 1 Assertions

Text. Plant reproduction was adequately explained in grades 4 and 5 (see concept maps). Differences and similarities between the interrelated concepts of pollination and fertilization were not clear. The proposition that "plants produce new plants of the same kind from seeds" was repeated in almost every grade. Most concepts related to seeds, parts of the seed, and germination were repeated in three or more grades.

Children. Though several students spontaneously mentioned the term and knew that reproduction is the process by which plants make new plants, all revealed misconceptions concerning reproduction. Several stated point blank that they did not know how plants reproduce.

For example, informant 6 (an honor student) recognized terms for reproductive flower parts on a multiple choice questionnaire but in the interviews she displayed various misconceptions about reproduction. She called flower petals leaves and stated that she did not think trees have flowers. When asked how the color helps the flower, she stated that the color attracts bees for pollination. Then she commented that she did not know what pollination means. She believed that if the seeds were very tiny, one would have to plant a large number of seeds to form one tree. She called oak catkins (which are flowers) seeds but said they were going to be flowers.

Though a few informants stated that bees collect pollen from flowers, no one understood the relationship of pollen to reproduction. Informant 1 knew that pollen was for "getting new plants," and then said that flowers don't have seeds, they have pollen instead. She and informant 5 believed that the pollen falls to the ground to make new flowers.

When asked the purpose of a flower, four informants said something about making seeds for new plants. Several informants said they did not know the purpose of a flower. Most informants were aware that "seeds" are attached to flowers, but no one knew how the seeds develop. Some informants did not know that flowers are related to seeds or fruits. Several said a flower is for beauty or to provide food for bees. Informant 3 suggested that a flower serves the function of catching water (like a cup) for the bush.

When asked the purpose of a seed, several said something such as, "To make more trees." All informants knew that if a seed is buried in the ground, a new plant will grow. Informant 9, however, believed that after a fruit falls from a tree and is buried in the ground it decays and the nutrients released cause a new tree to grow. Informant 2 said that when a seed in the ground gets wet, it "blooms" (germinates) and a plant will come up. Informant 7 confused reproduction with photosynthesis: "Veins take in light for reproducing."

One informant commented that she had observed reproduction in animals but had never observed it in plants. Actually, what she had observed was birth.

Additional studies. In the 1975 National Assessment of Educational Progress only 68% of 13 year olds selected "flowers" as the answer to the question, "Seeds come from which parts of a

plant?"

Reproduction: Level 2 Assertions and Recommendations for Educators

Some student misconceptions about reproduction may have been related to lack of ability to recognize flowers and fruits in their diverse forms. If students do not know the names for the parts of a flower, and are not aware that fruits form from flowers, can we expect them to understand the process of reproduction?

Research is needed to determine whether or not student misconceptions about reproduction can be changed or prevented by means of the following techniques: direct field observations and laboratory experiments (including observations with microscopes) with flowers and fruits that will enable the child to observe (1) the reproductive parts on diverse flowers, (2) the development of fruits from flowers, (3) the presence of seeds in diverse fruits, (4) new plants growing from seeds. If we can eliminate student misconceptions about the concrete aspects of reproduction (e.g., identification of stamens and pistils), will we find that the abstract aspects of reproduction (e.g., fertilization of the ovule) will be easier for the child to comprehend?

I recommends that field and classroom observations of plants and plant parts begin in kindergarten and continue through all the grades. Explanations of the rudiments of reproduction may be appropriate for the upper elementary years, but detailed discussion of the reproductive mechanisms may be too abstract for many elementary students. Discussion of reproductive details may only become meaningful when students have made enough observations to understand that there is a predictable progression from bud to flower to fruit, with seed enclosed.

Photosynthesis and Respiration: Level 1 Assertions

Text. Presented as a method of food production in plants, the process of photosynthesis was introduced in grade three and repeated in every grade thereafter. The term photosynthesis was not introduced until fifth grade.

Various statements in the texts may promote the misconception that plants get food from some other source (e.g., "energy is food," "plants get energy from food," "Venus flytrap gets minerals by eating insects," "water and minerals are nutrients," "plants need water and minerals," "nutrients are taken up by growing plants").

Respiration was explained in the fifth grade text. The fact that plants need oxygen for survival was not clearly stated in the text.

In grade 5, in discussing the carbon dioxide/oxygen cycle the text stated that in an aquarium, "Without the fish, the plants would die. Without the plants, the fish would die." The belief that plants receive all of their carbon dioxide from animals is a misconception.

Children. When asked the function of leaves, informants 5 and 7 said it was for storing food, but they did not know how the food got in the leaf. Informant 8 stated that leaves are for taking in carbon dioxide but she did not know how plants use carbon dioxide. Informants 1 and 2 both said that a leaf is to make the tree look good. Three informants said they did not know the purpose of a leaf.

The field research revealed that students have very little understanding of the concepts of photosynthesis and respiration. In the interviews I never introduced the terms photosynthesis and respiration and neither did the informants. Only informants 1 and 6 grasped the rudiments of photosynthesis and their knowledge was inconsistent.

Informant 1 said that plants don't need food because they get energy from the sun. She was unable to explain how plants use that energy. No one offered the information that plants make their own food. When asked if plants make their own food, informant 6 said yes, that they make their own food from water and sunlight. She was not consistent in this response. In another interview when asked to explain how plants get their food, informant 6 said that food comes from water and sun and soil.

Sample dialog:

Informant 6: "Well, soil gives them (plants) mineral like stuff. And water, they have to have water. Like we do. And so then they take them, and they put chlorophyll in them, and something like that. And then they mix them together and everything, and they put them in their veins."

Researcher: "How does the sun help the plant?"

Informant 6: "I don't know."

....

Informants 2 and 3 stated that plants don't get food, they get water. They were unable to explain how plants use water. Five informants stated that plants get food from the soil (or the water in the soil). Several stated that the sun gives plants energy, but others thought that plants get energy from the nutrients in the soil. Several stated that minerals in the soil supply the food. A couple of informants equated the term nutrients with food. Water was viewed as either food, nutrient, or the carrier of the minerals. Informant 2 said, "Plants eat by water. Also, they kind of eat sunlight."

Informant 7 said that trees respond to the sun by growing toward it. Then he added that trees respond to food by growing toward the food.

Informant 9 believed that plants get food and energy from the soil. Only informants 1, 6, and 7 volunteered the information that plants get energy from sunlight.

The students had grasped the idea that leaves are a site of gas exchange although that was not

what they called it. These students believed that the process of taking in carbon dioxide serves the same function as breathing oxygen does for animals. A few stated that plants do not breathe in the same way that animals do, but the students had no way of explaining gas exchange other than as a type of breathing.

The concept that plants take in oxygen eluded the informants in this study. Most stated that plants do not need oxygen. All informants but one mentioned that plants take in carbon dioxide, and all mentioned that plants let out oxygen. They knew that humans and animals rely on the oxygen produced by plants. The informants erroneously believed, however, that plants will die if animals are not around to supply them with carbon dioxide. The students did not know how plants use carbon dioxide or that there is a connection between carbon dioxide and "food" production. I did not ask questions about gas exchange and yet each informant spontaneously introduced the concept, typically when asked about the importance of plants to humans.

These students did seem to have a rudimentary understanding of gas exchange, as long as they could relate it to human breathing. Although the textbook example was of plant-fish interdependence in an aquarium, the students had successfully made the connection that humans also depend on oxygen produced by plants.

Additional studies. In the 1975 National Assessment of Educational Progress only 62% of 13 year olds chose "photosynthesis" as the response to the stem, "Green plants make sugar by the process called...." Only 50% of 13 year olds chose "produce food and give off oxygen" as the response to the stem, "Green plants are important to animals because plants...."

Other studies on children's conceptions of photosynthesis consistently reveal that most students have misconceptions. In a study of tenth grade biology students from seven schools, Simpson and Marek (1987) found that less than 5 % had a sound understanding of the concept of photosynthesis.

Numerous studies have shown that students believe that plants get food from soil or water or even from sunlight and air (Barker & Carr, 1989a; Osborne & Freyberg, 1985; Smith & Anderson, 1984; Smith & Lott, 1983; Wandersee, 1986). Smith and Lott (1983) concluded that children view "food" as any materials that are taken in by plants. If plants cannot get sufficient materials from the soil, some students believe that plants can compensate by getting food from air and sunlight.

Misconceptions about respiration also seem to be fairly common. In Australia, Treagust (1988) found that when tested on respiration only 16% of eight graders selected the response that plants use oxygen continuously. By twelfth grade, 65% percent responded correctly.

Photosynthesis and Respiration: Level 2 Assertions and Recommendations for Educators

The textbook was possibly the source of the students' misconception that if animals die, plants will run out of carbon dioxide and die also. This may be a common misconception among adult laymen, including teachers.

Photosynthesis is a highly abstract concept that is far from being well understood by scientists. The concept may not be appropriate for elementary science study.

At whatever age the concept is presented, some important modifications may be needed in the textbook information. As pointed out by Wandersee (1986), one can buy plant "food" in nurseries. As the text called minerals and water "nutrients," and nutrients are found in food, it was logical for the student to equate nutrients with food, thus coming up with the concept that plants take up food through their roots. Thus some misconceptions about photosynthesis seemed to stem from the manner in which many adults (and the text) use the word <u>food</u>. Children understand that food is something that animals (including humans) take in. Thus it is difficult to talk about food in relationship to plants without causing confusion about the meaning of the word <u>food</u>. Barker (1986) and Barker and Carr (1989a & b) have suggested that, rather than refer to photosynthesis as a method of food production, it would be more accurate to refer to it as a method of carbohydrate production and energy storage. They have developed and tested a model for teaching photosynthesis to 14 year olds in New Zealand.

<u>Plant Needs</u>

<u>Level 1 Assertions</u>.

<u>Text</u>. In each grade, the needs of plants were presented but the list changed from grade to grade. No attempt had been made to resolve the discrepancies between the lists. In a number of cases no reason was given for why plants need various things.

The following propositions were presented in the text:

- Plants need air, water, and sunlight to grow. Most need soil - grade 1

- Plants need air, water, and sunlight to produce food - grade 4

- Living things need food, air, water, and a place to live - grade 1

- Plants need water and minerals - grade 3, 5

- Plants need water, carbon dioxide, and energy from the sun to make food - grades 3, 5

- Living things/plants get energy from food - grades 3,4,5

- Plants need light to survive - grades 1,5,6

- Plants need food, water, and air to stay alive - grade 5

- Plants need minerals to perform the life processes - grade 5

Children. When asked what plants need for survival, the informants consistently listed "water, sun, and soil" (several added "good soil"). Informants 8 and 9 added carbon dioxide to the list and at some point in the interviews most informants (except informant 7) talked about carbon dioxide as a necessity for plants. The informants revealed a lack of knowledge and misconceptions about how plants use water, sun, and soil (see discussion of children's conceptions of photosynthesis, above). Informants 3 and 8 believed that rain water soaks in through the leaves and then the veins transport the water to the roots.

Level 2 Assertions.

The students' statements of plant needs were similar to the statements in the text. The students seemed to be reciting text-taught ideas from rote memory. The children may have learned that plants need water, sun, and soil from personal experiences at home (e.g., if they have a garden or houseplants) but their knowledge of why plants need things probably came from the text. Unfortunately statements in the text were poorly explained and inconsistent even though redundant. By not giving consistent information from grade to grade, the text may have left students with a partial understanding of the environmental needs of plants and little understanding of how plants use soil, water, light, and minerals.

Classification Schemes: Level 1 Assertions

Text. A disconcerting event happened between the third and fourth grade texts. In grade 3 the text stated that there are four main kinds of seed plants, "trees, shrubs, herbs, and vines." The text did not explain that this is not a scientific classification scheme. In grade 4 the text declared that plants can be classified by the way they reproduce. This is an example of a scientific classification scheme. Figures 16 and 17 present the classification schemes used in the third and fourth grade textbooks respectively.

The fourth grade text went on to classify seed plants as flowering plants and conifers, and to separate flowering plants into monocots and dicots. No attempt was made to demonstrate the relationship of the scientific classification scheme to the folk classification scheme (trees, shrubs, herbs, vines) presented in grade 3.

In grade 4, the text classified fungi as types of plants, slime molds as types of fungi, and blue-green algae as a type of algae. Modern taxonomists would disagree with these classifications. Some taxonomists do not consider all algae to be types of plants. For an example of a modern botanical classification scheme, refer to Figure 18, below, on the Kingdom Plantae. Three other kingdoms have recently been added to take care of various species that do not fit into either the Kingdom Plantae or Animalia. Kingdom Monera includes bacteria and cyanobacteria (formerly called blue-green algae). Kingdom Protista includes some algae, protozoa, and slime molds. Kingdom Fungi includes molds, mildew, mushrooms, yeasts.

The elementary text did not present the folk categories as though they have overlapping boundaries. For example, trees and shrubs were defined as though they are mutually exclusive categories. In the text the scientific concepts of the family, genus, and species were not presented before the seventh grade.

Although the text used the terms evergreen, conifer, deciduous, and broadleaf tree it did not define them accurately in relationship to each other. The concept evergreen tree was defined in the text as a tree that has needles. Only conifers were included in the examples of evergreens. The students used the terms in the same manner. In Texas numerous species of broadleaf trees and shrubs are evergreens, and one of our conifers, the bald cypress, is deciduous.

The fourth grade textbook had two excellent sections on tree identification, a short key to the leaves of six trees, and a section on how to distinguish the different types of conifers found in the United States. Unfortunately four of the six trees in the key do not grow in central Texas, and only one of the types of conifers found in the second exercise (cedar) grows there.

In the text some other plant categories also lacked well defined connections with other categories. For example, the reader may have been left wondering what kinds of things are green plants, cactus, and lichens.

Children. For a full discussion of the classification schemes of the informants, refer to the section "Categories for Plants." The scheme used in the third grade text overlapped with, but was not the same as, that used by the informants. The informants used the major categories trees, bushes, flowers, plants, vines, grass, cactus, leaves, and weeds. The terms shrub and herb were mentioned only once or twice by the students. Herbs was used only in a culinary reference. Some categories commonly used by the informants, notably grass and cactus, were not accounted for in the textbook classification scheme (even though the terms were used in the textbook). It was clear from the way the informants classified plants that the folk categories had a large degree of overlap.

The students did not use any major categories from the scientific classification scheme presented in the text, with the exception of the categories conifers (which was generally used accurately) and plants (which was generally overdiscriminated). The informants never referred to seed plants, monocots, or dicots.

Students had few accurate names for plants. For example, few students could name the different types of cactus seen. Despite the fact that pine trees were illustrated in the text in all grades, one of the informants stated she had never known how to recognize a pine tree until she identified one in the outdoor session.

Although students lacked knowledge of names for many plants, the interviews demonstrated that the students were capable of discriminating between specimens at the generic level (see the section "Names for Plants" for discussion). Though the students were not familiar with scientific names for plants, they showed a strong preference for the generic level in using common names.

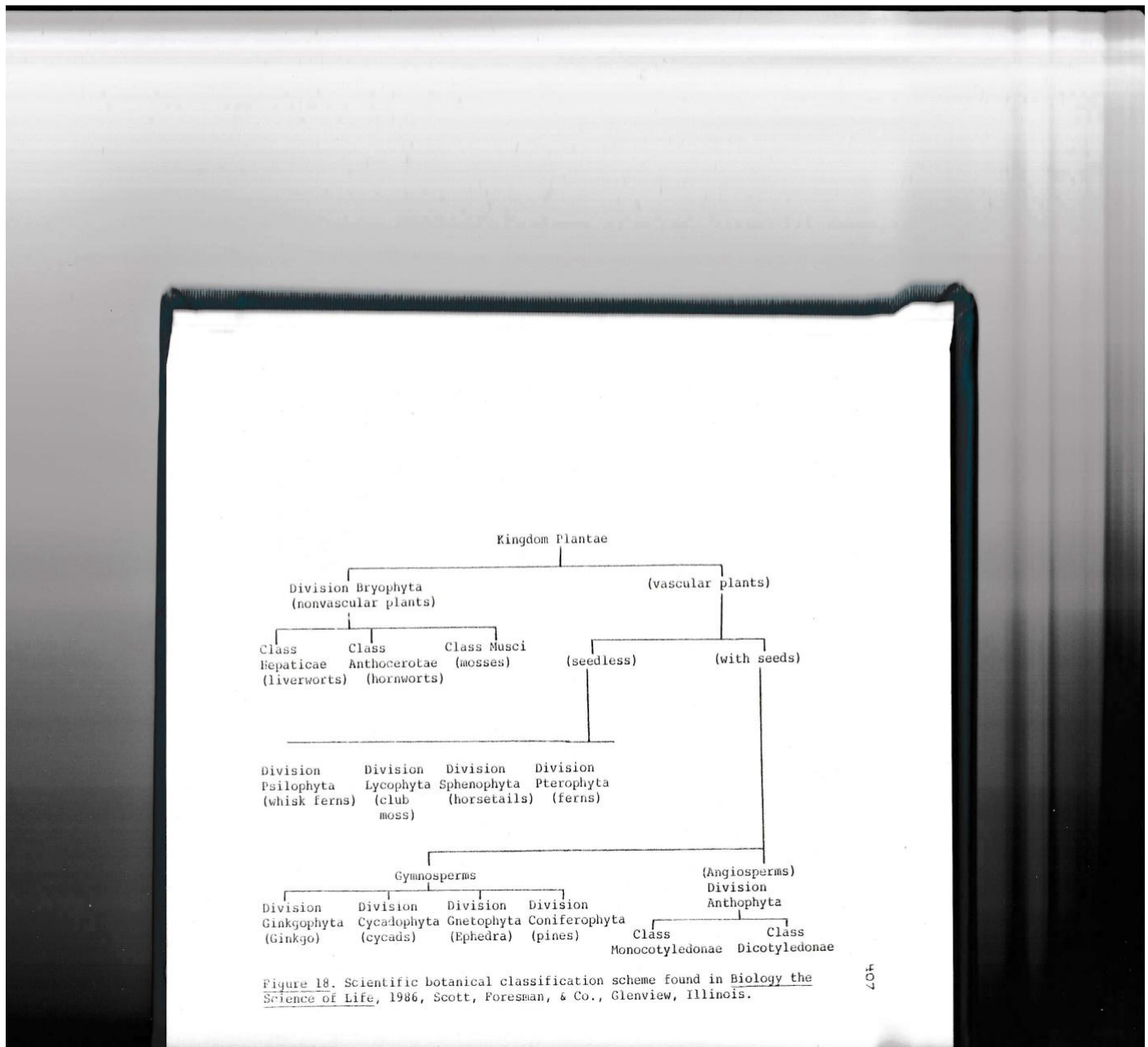Students also demonstrated abilities to recognize family relationships between plants.

Figure 18. Scientific botanical classification scheme found in Biology the Science of Life

Classification Schemes: Level 2 Assertions and Recommendations for Educators

Two important observations about student abilities must be made here. These students were capable of distinguishing plants at the genus and family level, and the students did have a viable folk classification scheme. The elementary textbook did not introduce the concepts of genus, species, or family, and the textbook did not bridge the gap between the folk and the scientific classification schemes presented in grades 3 and 4.

Berlin (1972) pointed out that folk classification schemes, at the generic and specific levels, are closely linked with the scientific scheme at the level of genus and species. Research by Stross (1973) demonstrated that children in rural Mexico can learn many generic and specific common names for plants at an early age. Evidence from the current study suggests that children probably can readily learn to recognize plant families as well. Thus the scientific concepts of species, genus, and family would be appropriate for elementary school science. The more abstract levels of the scientific hierarchy (e.g., monocot, dicot) probably should be omitted from elementary curricula unless the students have already mastered the lower levels of the hierarchy.

Before being introduced to a scientific classification scheme, the young child needs many opportunities to make guided field observations of plants. I recommend that teachers experiment with having students make their own folk classification schemes explicit. Examination of student's own classification schemes may be a meaningful way to introduce the concept of models, so important to the understanding of all scientific theories. The teacher could encourage the student to examine his or her own folk classification scheme and compare it with the schemes of other students. The upper elementary student could be encouraged to explore the ideas that (1) there are many different ways that plants can be classified, (2) classification schemes are devised by humans and are, therefore, artificial and can be altered as more information is gained, (3) botanists do not agree on one classification scheme, and (4) categories for plants (both folk and scientific categories) have overlapping boundaries.

Children need to be able to compare their folk categories for plants (tree, bush, vine, etc.) with scientific plant families (e.g., sunflower family, legume family) so that they can begin to understand the interrelationships between the two. For example, the legume family includes within it trees, shrubs, vines, and herbaceous plants. The sunflower family includes mainly herbaceous plants. Students need opportunities to understand the advantages of using a system based on reproductive characteristics (scientific classification schemes) over systems based on form (folk schemes).

Through the gradual introduction of a scientific classification scheme (starting with genus and species, and moving up to family), and through comparison with their own folk classification schemes, students may begin to understand the relationship and conflict between folk and scientific classification schemes. Once the students comprehend that plants include woody plants

(trees, bushes) as well as non-woody plants, the teacher can introduce the concept that flowering plants differ from conifers and that a number of other plants (such as ferns) do not fit into either group. While young children can certainly learn the names for the categories algae, lichens, and mushrooms, the hierarchical relationships of these objects can wait for high school.

Human Uses of Plants/ Human Dependence on Plants

Level 1 Assertions.

Text. The text provided some good information on human uses of plants, but only in grade 3 which devoted one full chapter to the topic. In grades 1,2,4, and 6, only two sentences each mentioned human uses. In grade 5 there was no information on human applications.

In grade 3 the statement was made that, "plants are the most important living things." The statement was not explained. Limited information on food chains was given in upper elementary grades (see the section on ecology, below), and the importance of plants as sources of oxygen was only mentioned in an aquarium example (see the section on photosynthesis, above).

Children. The data from the listing task indicate that children remember names of plants with human applications. Informants' lists of vegetables and fruits typically were longer than for most other categories of plants. Most of the names for trees and flowers were of edible or useful species.

Although all informants were able to list some plant products when asked specific questions such as, "What do humans get from trees?," they did not provide much information on this topic.

When asked what would happen if all the plants suddenly disappeared, seven informants stated that humans and animals would die due to a lack of oxygen. Five informants said that animals would die due to a lack of food. These informants gave accurate examples of food chains. The informants had trouble listing any other consequences. One informant added that we would lose certain medicines that are obtained from plants, one individual talked about the loss of lumber and other wood products, two commented that the world would not be very pretty, and one commented that the birds would not have a place to live. Informant 7 also stated that the wind would stop because the movement of the trees causes the wind to blow.

No other consequences were stated by the students. The informants clearly had not previously been consciously aware of how important plants are to human existence. For example, after responding to this question, informant 5 expressed amazement at her sudden realization of how important plants are to humans.

Level 2 Assertions and Recommendations for Educators.

The data indicate that students remember best names for plants that have relevance to their daily lives, such as plants that produce foods or other useful products. And yet the informants

apparently had little awareness of the importance of plants to human existence. This type of understanding is critical to the development of an environmental ethic and environmental decision making.

Information on human dependence on plants should be a major part of every grade, and yet it was missing from most of the text. Students may show more interest in learning about plants if they understand the important role plants play in everyday life.

Ecology/Environmental Biology

Level 1 Assertions.

Text. In grades 4, 5, and 6, the text provided good (but limited) information on ecology, particularly on plant adaptations. Rather than providing a variety of concrete examples of adaptations, some of the same examples were repeated in later grades. Information on the flow of energy and matter was presented in a confusing and inaccurate manner. The seventh grade life science text duplicated much of the ecology information presented in the elementary texts. The texts included no information on environmental issues related to plants (such as the effects of pollution, deforestation, and endangered species) or plants as renewable resources.

Table 18 (below) lists the number of pages in each grade devoted to ecological concepts. Grade 4 included a discussion of food chains and food webs and plant adaptations. Grade 5 included one full chapter on communities. Grade 6 had one chapter on plant growth and responses (19 pages), and one chapter on biomes (25 pages). Only one desert was depicted in all seven textbooks. The text oversimplified the desert, a very complex ecosystem.

Table 18: Ecology Coverage in the Elementary Textbook Series, Silver Burdett Science

Grade	Page ratio	Percentage
1	0	0
2	0	0
3	0	0
4	16/290	5
5	20/334	5
6	44/336	13

In grade 5 Chapter 4, the concept of plant succession was discussed. The classic example, the eastern deciduous forest, is an unknown entity to children in central Texas. The concept of a climax forest may be meaningless to children growing up in a disturbed grassland habitat.

Children. Despite limited coverage of the concept in the text, in the interviews five informants spontaneously provided accurate examples of food chains, and all understood that plants are basic to the food chain.

<u>Level 2 Assertions and Recommendations for Educators.</u>

The fact that the food chain was virtually the only abstract botanical concept accurately represented by the students indicates that ecological topics are appropriate for upper elementary science. In the 1979 National Assessment of Educational Progress (1979a) it was found that nine year olds recognize the seriousness of environmental issues but have had little experience in working with these issues in school.

Based on the results of the current study and recommendations of the AAAS (1989), I suggest the following changes to the text. The textbooks need to include more concrete examples of food chains, food webs, plant and animal interactions and interdependence, habitats and niches, population, community, ecosystems, and biomes. Regional supplements are needed on local biomes, ecosystems, food webs, and adaptations of native plants to local environment.

Information on the factors leading to the need for adaptations would be useful. In grades four and six, examples were given of adaptations for conserving water. Since evapotranspiration is the cause of water loss, this concept needs to be introduced and explained in a concrete manner before the related adaptations are discussed.

Discussion of the effects of pollution on plants, plants as renewable resources, and endangered species are appropriate for upper elementary grades but were missing from the texts analyzed. Student attitudes and values related to these topics can be addressed in classroom discussion.

<u>Further Recommendations for Educators</u>

<u>Abstract Botany Concepts to Omit from Text.</u>

Other abstract concepts mentioned in the text were not examined in the field research. Based on the problems students had with photosynthesis and reproduction, this researcher recommends omitting the following abstract concepts from the elementary science text: mitosis, chromosomes, genes (although the concept of inherited traits can be demonstrated to young children, particularly in relationship to human traits, it is not essential that elementary students understand the mechanisms behind inheritance); tissues, organs (the researcher recommends leaving these concepts out of elementary text, except to teach children the names of human organs); biological clock (if introduced, should include more concrete examples and a better explanation); birth rate, death rate, critical factors (these concepts were undefined in the text and should be omitted).

Some information in the text had a regional slant that is not appropriate for a text that is used nationwide. For example, some textbook information on seasons was not applicable to seasons in Texas and other areas of the south. A picture of a garden may signify summer to someone living in New Jersey (where many of the textbook writers live) but it can signify either spring or fall to a Texan. In Texas, many seeds germinate in winter, many flowers bloom in fall and late winter, and many trees remain green throughout the winter. Temperatures in the 80's can fool a child into thinking that it is summer in February. Textbook writers need to be very careful of how they

present seasons in nationwide texts.

Abstract Concepts to Add to Text.

The AAAS (1989) has recommended four major areas for concept development in biology. Two of those areas relate to botany: the evolution of diverse life-forms and environmental biology. Within the study of the living environment, the AAAS has recommended study on the diversity of life, heredity, cells, interdependence of life, flow of matter and energy, the study of food chains and ecosystems, and the evolution of life. The association also has recommended study of the reliance of humans on plants for survival, food, and other needs; sustainable agriculture; renewable resources; and the effects of pollution.

Most of the areas recommended by the AAAS are inadequately covered or missing entirely from the elementary text. As mentioned above, a few of the concepts recommended by AAAS are inappropriate for lower elementary science (e.g., cell theory), but others (e.g., food chains) can be introduced with concrete examples on a level that is appropriate for upper elementary grades.

Two areas of study mentioned by the AAAS have not been discussed above. The diversity of life and interrelationships between life-forms can be introduced in elementary school science through field observations of plants and animals. Evolution was not mentioned in the elementary text. Human evolution is the most interesting way to introduce the topic. Plant and insect co-evolution may be appropriate for upper elementary study if numerous concrete examples (including in films) are used.

Pedagogical Emphasis of Text

Level 1 Assertions

The AAAS (1989) has pointed out the importance of the study of the nature of science (the scientific world view, scientific inquiry, and the scientific enterprise), historical perspectives of the development of scientific theories, common themes (systems, models, constancy, patterns of change, evolution, and scale), and habits of mind (values, attitudes, and skills). The AAAS has recommended that topics such as societal/environmental issues in science, the history of science, careers in science, and student attitudes and values related to science be included in school science.

Virtually all of these aspects of science study seemed to be missing from the botany related text. The text presented none of the history of how botanical concepts were developed and made no mention of the controversial nature of botanical theories (e.g., theories of plant evolution). Scientific classification schemes frequently go through revisions, with botanists differing in opinion as to which system more accurately reflects evolutionary trends and family relationships. None of this was portrayed in the texts. [Note: In the 30 years since this dissertation was completed in 1990, the many advances in DNA analysis have dramatically altered some plant classifications.]

The scientific processes used by botanists to study plants were not mentioned. Most experiments in the text were either used to confirm text-taught facts or to provide observations of text-taught facts (vegetables contain starch; seeds contain oil). A couple of exercises provided practice in using, but not in developing, plant keys. Only two experiments required the student to draw conclusions not already provided in the text. One of those, an experiment designed to show why "plants in the desert don't have leaves," promoted a misconception (in fact, many plants in the desert do have leaves).

Careers in botany were not mentioned and human applications of plants and human dependence on plants was given little coverage in the elementary text. Societal issues related to plants (such as the effects of deforestation) were not discussed. [Note: In 2021, climate change would be a crucial concept to develop in elementary textbooks.]

In a position statement developed in 1982, the National Science Teachers Association (1982a) recommended goals for the percentage of instructional time devoted to process skills, concept development, human application, and science-based societal issues in each grade (see Staver and Bay, 1987). In kindergarten, the NSTA recommended devoting about 66% of instructional time to the development of process skills. By sixth grade, time spent on skills should drop to about 37%. Concept development should only take 25 to 40 % of class time in sixth grade. Human applications should take about 10 to 25 % of instructional time, with societal issues 0% in kindergarten, and about 15% by sixth grade.

In their textbook analysis (which included the 1984 Silver Burdett series), Staver and Bay (1987) found that the vast majority of each text analyzed concentrated on academic concept development.

In the current textbook review, with the exception of limited information on human applications and ecology, virtually all of the botany related propositions consisted of academic science concepts. Abstract concepts were emphasized. Although concept development is an essential aspect of learning science, the concepts presented in the text often lacked appropriate concrete examples that would enable the child to comprehend them. And the text virtually ignored the concepts that have most relevance to the life of the child, such as human uses of plants, and the development of process skills, such as classification, prediction, and hypothesis testing, that are even more important to the scientific endeavor.

Level 2 Assertions

The textbook was not designed to reflect the knowledge base of the elementary student. This omission was most apparent in the textbook discussion of plant classification. No attempt was made to bridge the gap between the folk classification scheme of the child and the scientific classification scheme.

The traditional lecture approach, with an emphasis on science fact rather than science process, persisted in the textbook. The text presented botany as a body of knowledge rather than as a way

of thinking. The text has clearly failed to meet the needs of the students and has failed to fulfill the recommendations for science education made by the NSTA and the AAAS.

Textbook Concepts Compared with the Conceptions of the Child: Summary

In summary, the analysis of the elementary textbook series *Silver Burdett Science* resulted in description of three main aspects: the language of the text, concept development in the text, and the pedagogical emphasis of the text.

Analysis of the language of the text revealed that a large percentage of the names for plants used in the text would be unfamiliar to children in central Texas. I have suggested that using unfamiliar plants as examples tends to place the concrete in the realm of the abstract.

The text used a large number of scientific vocabulary words, not all of which are necessary to the understanding of botanical concepts. Many of the botanical terms were either not defined explicitly, were not used in context on more than one or two occasions, or were not adequately illustrated with either visual or verbal examples. I have asserted that in general the text has failed to present new vocabulary in a manner that would enable the novice to acquire its meaning.

Analysis of concept development in the text revealed that a disproportionately high percentage of concepts introduced by the text were abstract. Connections between concepts were generally present in the text but I question whether or not the child would be able to understand interrelationships between concepts without the use of a visual guide, such as concept maps. Concept development in the text was found to consist of from two to ten hierarchical levels. I have called into question the ability of students to learn new scientific concepts with the degree of complexity presented in the text.

The number of false and misleading statements found in the text has indicated that some of the students' misconceptions may be the direct result of errors in the text. It was not possible within this research to determine whether the children learned these errors from the textbook or whether the students already had been exposed to these errors before reading the text. Whether or not students' misconceptions were caused by errors in the text, false and misleading statements in the textbook would promote and reinforce those misconceptions.

A high degree of unnecessary repetition of topics was found in the elementary and middle school texts. I have suggested that removal of redundant material would greatly reduce the amount of material teachers feel compelled to cover each year.

In comparing concepts presented in the text with the children's conceptions, it was found that the children had a poor understanding of many of the concrete and abstract concepts found in the text. The children gave incorrect or incomplete interpretations of concepts related to photosynthesis, respiration, reproduction, cells, plant needs, differences between living and non-living, and differences between plants and animals. They had a poor understanding of the importance of plants for human survival. The students did have knowledge of various human uses

for plants and were able to give accurate examples of food chains.

The children were unable to identify some plant parts (e.g., flower parts) and did not understand the functions of some plant parts (e.g., leaves). This lack of knowledge may be an important factor in the students' misconceptions about reproduction and photosynthesis. Misconceptions about parts of plants are likely to be the result of little guided experience with the diverse forms that leaves, flowers, and fruits can take. These types of misconceptions may be easy to remedy with hands-on field based experiences with plants.

Children's lack of knowledge of the scientific classification scheme is probably a result of the fact that the children used a folk classification scheme that differed in important aspects from the scientific scheme. The text did not provide information that would allow the child to bridge the gap between the folk and scientific classification schemes.

Analysis of the pedagogical emphasis of the text revealed that the text has presented science as a body of facts rather than as a process. In its pedagogical emphasis, overuse of abstract academic concepts, neglect of concepts related to evolution, human use of plants, ecology and societal issues, and its lack of inquiry based experiments , the textbook clearly did not reflect the recommendations for science education put forth by the AAAS and the NSTA.

CHAPTER V - SUMMARY AND RECOMMENDATIONS

In summary, this study examined the following aspects of children's knowledge of plants: names for plants, responses used when children do not know names for plants, basic levels of abstraction in naming plants, categories for plants, hierarchical relationships between plant categories, names and functions for parts of plants, children's explanations of abstract botanical concepts. Botanical concepts found in the textbook were evaluated and compared to the children's conceptions. Refer to the summary at the end of the sections in Chapter IV for a review of the assertions made from the data presented in this study.

From the analyses of children's botanical knowledge and the comparison with the text, the following questions have been addressed. Are the language, meanings, and classifications of the child similar to that of the adult layman, the textbook, and/or the botanist? Are children's concepts naive, idiosyncratic, based on folk knowledge, or based on scientific knowledge? What are the children's areas of strength and weakness in their botanical knowledge? How do the children organize their botanical knowledge? How well does the botany related text fulfill the recommendations for science education made by the NSTA (1982a & b) and the AAAS (1989)? How well does the text bridge the gap between the conceptual framework of the child and the scientist? One final question must be addressed before this study ends: why should children study botany?

My responses to these questions have been included below. Following that discussion, the limitations of the study have been evaluated. Finally, the implications of the study for future

research (both in science education and in cognitive psychology) and for science education curricula are discussed.

The Questions

Are the Language, Meanings, and Classifications of the Child Similar to that of the Adult Layman, the Textbook, and/or the Botanist?

Many of the scientific botanical terms found in the text were never used by the informants in this study (e.g., monocot, dicot, photosynthesis). For other scientific terms, it was apparent that the children had poor understanding of their meanings (e.g., pollen, stamen). Many botanical terms are commonly used by adult laymen (leaf, flower, petal, seed). The research has demonstrated that the children in this study used many of the same folk botanical terms that the adult layman would use. The children sometimes did not use these terms accurately, particularly in referring to parts of plants.

Most of the children's names for plant categories were similar to those of the adult layman. In most cases the meanings for those terms were reasonably consistent with adult lay usage. Students' meanings for some categories (particularly tree, vine) would be acceptable to a botanist. Some botanical terms (e.g., fruit, herb) have different meanings in the folk culture and in the scientific culture. The children's uses of these terms indicated that they were using the folk cultural meanings rather than the scientific meanings.

Are Children's Concepts Naive, Idiosyncratic, Based on Folk Knowledge, or Based on Scientific Knowledge?

Although each child had certain idiosyncrasies (for example, differences in what specimens would be called <u>bushes</u>), there were many similarities between informants in overall meanings for categories (particularly prototypes), criteria for category selection, and other aspects of their botanical knowledge. Some misconceptions about abstract concepts (e.g., how plants get "food") were shared by the majority of the informants. These trends suggest that children's knowledge is less idiosyncratic than might have been assumed previously.

Some botanical concepts clearly have been learned as part of the language and meanings of the folk culture. Names for plants, names and meanings for plant categories, and the hierarchical relationships between plant categories all have a basis in folk cultural knowledge. The children's concepts in these areas are not naive or idiosyncratic, rather they have probably been learned from parents and peers. Even though some of the names and meanings for these concepts may not be acceptable from the point of view of the scientific framework, they do have validity in the framework of the folk culture. Thus the data from this study lend support to Hills' assertion (1983) that the knowledge of the child is based on a commonsense (folk) theoretical framework.

Some student explanations were apparently based mainly on text-taught terminology and it was clear that the students had a poor understanding of that terminology. This might indicate that

virtually all of the child's knowledge for that subject was derived from the textbook and that the child did not have any prior knowledge in that area (e.g., photosynthesis, reproduction, the environmental needs of plants, and the "life processes"). When explaining some abstract botanical concepts, however, some notions from folk knowledge (e.g., that plants get "food" from the soil) played a role in the children's interpretations.

In some cases, the children did have experience with the phenomenon even though they had not learned the scientific explanation for that phenomenon. For example, the children in this study knew that plants need soil, water, and sunlight. This knowledge was likely to have come from first-hand experience and folk cultural knowledge as well as from the text. Knowledge of how plants use sunlight, water, and soil, however, is probably not part of the folk cultural knowledge. As has been shown in the textbook analysis, the textbook did not always provide enough information to fill the gap between the knowledge available to the child from the folk culture and the knowledge available to the botanist from the scientific culture. Thus the child's explanations of some abstract botanical concepts tended to be idiosyncratic, based on a mishmash of text-taught terminology and folk knowledge, with little understanding about how the two fit together.

In examining elementary children's explanations for biological phenomena, Lawson (1988) concluded that there was little evidence that the children had any self-generated theories. The concepts he studied were mostly abstract concepts (photosynthesis, reproduction, cell theory). The current data suggest that explanations of some phenomena (typically, tangible phenomena) are derived from the folk cultural knowledge or are idiosyncratic interpretations based on folk cultural knowledge. When the phenomena are not observable, the children typically do not have theories and will tend to fall back on text-taught ideas, which are often poorly understood.

Some student misconceptions may have been learned directly from the text. For example, the idea that plants rely on carbon dioxide from animals was an erroneous concept found in the text. This misconception may also be part of folk cultural knowledge.

In summary, the children's explanations for botanical phenomena came partly from the folk culture, partly from idiosyncratic interpretation, and partly from the text.

What are the Children's Areas of Strength in Their Botanical Knowledge?

In the free listing task, the children remembered best the names for useful plants. Some children performed fairly well in the plant identification task. Although no one had a large number of accurate common names for plants, all children displayed abilities to distinguish between plant specimens at the generic level. When naming plants, errors of overgeneralization revealed that the children recognized similarities between species belonging to the same botanical family.

In naming plants, students' wrong answers represented educated guesses rather than random responses. Types of errors made in naming plants (e.g., calling closely related species by the same name) suggested a greater knowledge of plants than the number of errors alone implies.

Several students gave richly detailed descriptions of plants. These descriptions were indicative of good observation skills. Most students displayed good classification skills. Several children excelled in their conceptions of plant categories, using names that would be familiar to botanists and selecting specimens that would be acceptable to a botanist. Most of the children's plant categories (e.g., trees, flowers) were based mainly on structural (rather than subjective) criteria. There was general agreement among students concerning what characteristics were valuable in defining categories. Characteristics used to describe plants and to distinguish categories often were the same characteristics that a botanist would choose.

It was of interest to note that the children who performed well on the plant classification tasks performed poorly in the plant naming tasks and scored low on their science achievement test scores. The students who performed the best in the plant naming tasks scored very high on science achievement test scores but performed rather poorly on the plant classification tasks. More research is needed to examine the factors that may influence student performance. The data suggest some possible factors.

Learning names for plants is a rote memorization task whereas classification of plant categories is a process skill. Are the achievement tests examining only rote memorization and overlooking children's abilities to perform process skills?

The children in this study were asked about their play preference (indoor versus outdoor, see Table 1). The informants who performed best in the plant naming task (informants 5 and 6) preferred outdoor play. Of the three informants who performed best on plant classification (informants 3,7,9) two preferred outdoor play. The informants who preferred indoor play typically performed less well on both tasks, regardless of achievement test scores. The amount of time children spend playing outdoors may be the most important non-school influence on their botanical knowledge and skills.

The children displayed a preference for naming plants at the generic level of abstraction (e.g., oak) rather than at more abstract levels (e.g., tree, plant). The generic level appears to be psychologically basic even in a culture in which knowledge of generic common names is largely lacking. The research suggests that children desire to identify objects at the level of abstraction at which they can easily recognize them. Children can differentiate between trees, therefore they want to demonstrate that ability by naming the types of trees. When children do not know the generic names for trees and other plants, they use a variety of strategies (e.g., saying, "I don't know," or giving no response) to avoid giving a more abstract response.

What are the Children's Areas of Weakness in Their Botanical Knowledge?

Students' misconceptions and lack of knowledge in botany cut across all individual differences. Regardless of gender, ethnicity, or achievement test scores, all children had major misconceptions about scientific concepts, both concrete and abstract.

The plant naming tasks revealed that student concerns affect how they respond when they do not

know the generic names for plants. All children used strategies that allowed them to avoid either admitting ignorance or giving a wrong answer. The research suggests that students are afraid to make errors. Students' strategies for coping with their lack of knowledge may mask low self-esteem and other fears.

Several students with high achievement test scores had rather poor classification skills. One child relied on irrelevant attributes such as backgrounds in the photograph (e.g., sunset colors) for category selection. Children's lack of knowledge about names for plant parts suggests that they had had few guided field experiences with plants. Some plant categories (e.g., flower, weeds, plants) were based on subjective criteria (e.g., prettiness) or unstable criteria (e.g., seasonal attributes, such as presence or absence of flowers). Such categories had extreme overlap, with species appearing in one or more groups under different conditions.

The children's explanations for many abstract botanical concepts (e.g., reproduction) revealed that they had not previously put much thought into the meanings of the concepts. The children probably had not previously expressed their knowledge about topics such as the differences between living and non-living, plants and animals, and human dependence on plants. The good news is that these concepts may not be dogmatically embedded in their minds, and thus may not be particularly resistant to change, as long as the scientific explanation can be seen to make sense in relationship to the folk explanation. Children's concepts, although tenacious (i.e., long lasting) may not truly be resistant to change. It may simply be that no one has ever showed the students the relationship of their folk knowledge to scientific knowledge, thereby enabling them to bridge the gap between the two.

How Do Children Organize Their Knowledge?

Three areas of children's knowledge are mentioned here.

1. Knowledge of abstract botanical concepts. The children's knowledge of abstract concepts seemed to be poorly organized, a mishmash of folk knowledge, scientific knowledge, idiosyncratic interpretation, and vain attempts to sort all this out.

2. Categories for plants. The children organized plants into categories. The categories used most frequently by the children were trees, flowers, bushes, plants, vines, grass, cactus, leaves, and weeds. In choosing specimens for plant categories, the children seemed to use two types of categories: polythetic, with category membership depending on degree of resemblance to a prototype (e.g., trees); and monothetic, with category membership dependent of the presence of a few critical (necessary and sufficient) criteria (e.g., flowers). Regardless of category type, category membership was generally based on resemblance to a prototype. Inconsistent members indicated that several categories were also used as residuals, dumping grounds for otherwise unclassified specimens. Categories seemed to differ in salience, with the less salient categories (e.g., weed, bush) acting as residuals.

Although the specimens selected for plant categories differed widely between informants, the

prototypes were often similar (Kempton, 1981, also found this trend). The prototype may form the basis for common understanding and allow communication to be possible even when there are large idiosyncratic differences in reference.

Why do people use a prototype in classifying natural objects? Rosch and Mervis (1975) have suggested that the prototype, because it incorporates the largest number of attributes of the category, provides a model against which the individual can quickly match new objects. The prototype allows the individual to classify an object rapidly, sidestepping the lengthy cognitive process that would be involved if the individual had to judge the new object on the basis of its various attributes.

The informants' folk categories for plants typically had overlapping boundaries. For example, there was a gradation from <u>tree</u> to <u>bush</u>, with some specimens that were clearly members of only one category and others that might fit into either category. No necessary and sufficient criteria for category membership existed. These categories were defined by a prototype with extension.

Other categories (<u>plant</u>, <u>flower</u>, <u>weed</u>) had extreme overlap but no logical progression from one category to the next. For these categories, specimens that did not fit the one or two critical criteria of the prototype were not included and there was no gradual extension away from the prototype. Most children had some degree of awareness of overlap between their categories. In certain cases, however, several children seemed to think that overlap did not exist.

In the textbook analysis, the researcher found that the text tended to present botanical categories as though they did not have overlapping boundaries. The definitions given promoted the myth that for all categories there is some set of necessary and sufficient attributes that can be said to be possessed by all members of the category. In a survey of seven adults (three botanists and four college educators) it was found that four thought of plant categories (<u>tree</u>, <u>bush</u>, <u>cactus</u>) as not having overlapping boundaries. Two of these were botanists (Tull, 1989). The data suggest that it is common for adults to think that their categories are clearly defined and unambiguously bounded.

Werner (1985) suggested that in our minds we think that our concepts are clearly bounded and defined by necessary and sufficient conditions, while in the real world we treat them as though they are not. Rosch and Mervis (1975, p. 583) suggested that the reason people tend to believe that all members of a category have many attributes in common is that the "most typical items of each category tend to have many items in common." When thinking about the members of a category we tend to think only of the prototypical members, not the atypical members.

3. <u>Children's plant classification schemes.</u> Although they did not use a scientific classification scheme, the students' in this study did have a classification scheme that would be recognized by the adult layman. The children organized their categories hierarchically, although the hierarchies were in many cases poorly defined and fluctuating. Only six informants knew that trees are included in the concept <u>plants</u>. Even these informants tended to use <u>plants</u> mainly in reference to herbaceous, non-flowering plants, however. The children tended to have a binary division of

plants, with <u>trees</u> and <u>plants</u> at the top of the hierarchy.

Due to boundary overlap and polysemantic use of the category <u>plants</u>, the informants' categories did not maintain a constant relationship to each other. In addition, cultural differences may have caused some students to have trouble understanding questions about set inclusion (e.g., an African-American informant seemed to have trouble understanding the statement "a tree is a type of").

The hierarchical model developed by Berlin, Breedlove, and Raven (1973) worked reasonably well in examining the students' taxonomic hierarchies. Modifications to that model are needed to account for residual categories and fluctuating hierarchical relationships. In addition, overlapping boundaries were not accounted for in the model used by Berlin et al., even though overlap was apparent in their ambiguously affiliated generics.

How Well Does the Text Fulfill the Recommendations of NSTA and AAAS?

As have previous textbook analyses, the current analysis adds fuel to the argument that science textbooks do not promote the stated goals for science education put forward by the National Science Teachers Association (1982a & b), the American Association for the Advancement of Science (1989), and other education organizations.

The textbook review provided an in depth analysis that helped explain some of the factors that may prevent textbooks from providing a meaningful learning experience for children. Analysis of the language used in the elementary textbook series, *Silver Burdett Science*, revealed that a large number of the names for plants would be unfamiliar to the children in this study. Using unfamiliar plants as examples tends to place the concrete in the realm of the abstract. The text used a large number of scientific vocabulary words, possibly placing a cognitive overload on the young child. Many botanical terms were either not defined explicitly, were not used in context on more than one or two occasions, or were not adequately illustrated with either visual or verbal examples. Less than half of the botanical vocabulary used in the text was presented in a manner that would enable the novice to acquire its meaning.

A disproportionately high percentage of concepts presented in the text were abstract. I question whether elementary students have the ability to learn the abstract concepts presented in the texts, particularly with the degree of complexity used by the texts. The text presented a number of false and misleading statements about botany related concepts. In addition, a number of topics were unnecessarily repeated in the texts.

Overemphasis on academic and abstract concepts and scientific vocabulary indicate that the textbooks have placed an emphasis on science as a body of knowledge rather than as a way of thinking. In its pedagogical emphasis, neglect of concepts related to evolution, human uses of plants, and ecology and societal issues, and in its lack of inquiry based experiments, the textbook clearly did not reflect the recommendations for science education put forth by the AAAS and the NSTA.

How Well Does the Text Bridge the Gap Between the Conceptual Framework of the Child and the Scientist?

The text did not bridge the gap between the child's folk knowledge and scientific knowledge. The relationship between folk cultural and scientific knowledge (e.g., the plant classification schemes used by both) and the natural abilities of the children (e.g., ability to identify plants at the genus and family level) were largely ignored by the text.

Through false and misleading statements the text may initiate but certainly perpetuates a number of student misconceptions. The language of the text may also promote misconceptions when folk meanings conflict with scientific meanings and when scientific terminology is inadequately defined and illustrated.

Posner (1983) has asserted that students will not change their explanations for scientific phenomena unless they are dissatisfied with their existing conception. As presented in the text, the explanations for scientific phenomena probably do not challenge the students' existing ideas related to concepts such as plant classification. This may partly explain why the students' ideas have not changed after exposure to text-taught ideas.

Why Should Children Study Botany?

Lack of knowledge of plant names and misconceptions about plant categories is a result of the increasing complexity of our society. Survival no longer depends on the ability of every individual to identify wild plants and to know which are edible, medicinal, or poisonous. Nonetheless, plants maintain an indispensable role in our daily lives. Plants provide us with food, shelter, clothing, and medicine. They provide us with oxygen, moderate our climate, and ameliorate the harmful effects of pollutants. And yet many people are ignorant of the role that plants play in human survival.

It is no longer necessary to be able to recognize the names of wild plants as a means for daily survival. But learning the names and uses of wild plants and learning to appreciate plants strictly for their beauty is a valuable tool for awakening the child's awareness to the critical need for the preservation of all plant species. Children need to understand that our survival depends on the survival of plants.

The children of today will be the scientists of the future. The study of botany remains essential to several fields, including medicine, agriculture, and industry. Approximately 35% of prescriptions written in the United States today include a plant product as one of the major ingredients. Since the 1940s chemists have discovered more than 3300 alkaloids and 2000 organic compounds by analyzing plant material. These compounds have value in medicine and many other industries. In recent years, an important drug in the treatment of childhood leukemia was extracted from a wild periwinkle. The World Health Organization has concluded that only by using traditional herbal medicines can we meet the minimum health needs of the developing nations by the year 2000.

Wild plants still are valued in agriculture. Many wild plants that are naturally resistant to disease and drought have potential as food crops. Plant products are critical to many industries. Research and development on new sources of natural rubber is being promoted today as the demand for rubber will soon exceed the supply. The cosmetics industry utilizes a number of plant products. The demand for plant textiles (cotton, linen) remains high, despite the development of textiles from petrochemicals.

Today we are experiencing a worldwide loss of plant diversity. Many plant species are in danger of extinction, monocultures in agriculture have altered significant areas of the earth, and forests have been depleted to provide firewood for much of the world and to make room for agriculture, industry, and housing. With the decrease in diversity has come a loss of soil and an increase in crop damage from insects and other pests, both of which have a severely detrimental effect on the world food supply. Deforestation and slash-and-burn farming practices are contributing to the increase in carbon dioxide in the atmosphere, which are causing a global warming trend.

If children are not allowed opportunities to learn about the effects human activities have on plantlife, how can we expect them to take an interest in the preservation of plants? The poor performance of students indicates that the study of botany is largely neglected in schools today. And yet botany is more important than other fields of science because plants, the producers, the mainstay of the web of life, the regulators of our environment, are vital to our very existence.

Limitations of the Study

As does any type of research, qualitative research has its own strengths and weaknesses. The goal of this study was to provide a large base of data related to children's knowledge of botanical concepts. The enclosed report attests to the fact that much data were generated and that the data have relevance to science educators and those interested in the study of the factors that affect learning and cognition.

Although the study was conducted with a small number of informants, a large amount of data was collected from each individual. The use of a variety of types of tasks, both structured and unstructured, provided triangulating evidence in support of the internal validity of those data. Despite the differences in gender, ethnicity, and achievement test scores between the students in this study, much of their performance was remarkably similar (e.g., all had misconceptions about reproduction, and all either had concerns about admitting ignorance or being wrong). It would be useful to know the distribution of specific trends in the larger population. For example, the slide task could be given to entire classes to find out whether any particular group (based on gender or ethnicity) relies on particular response strategies more than others.

The recommendations for education have been offered with the assumption that the trends found in this study are not limited to these nine children. The purpose of the research is to build theory. One cannot build theory without making assertions based on the data at hand. To progress from there, one must assume that the assertions have value for individuals outside the study and then test the assertions under different conditions to find out in what types of cases they are viable and

in what types of cases they are not.

I would like to know to what extent the trends found in this study apply to other children as well. Some of the children's responses could have been due to the influence of one or two teachers that they had in common. Thus it would be useful to conduct similar types of studies with children in different parts of the country. There were some remarkable similarities between the responses of the children in Dougherty's study in California (1979) and the children in Texas. Other such comparisons need to be made to provide evidence to support or refute the external validity of the data collected in Texas.

Other limitations of the research need to be addressed. As the data were collected and analyzed by one person, my insights and assertions were informed by my own biases and background. For example, I have noted in retrospect that in the textbook analysis, I tended to point out the failings of the text and did not expend much effort evaluating what worked in the text.

More than in quantitative research, the personality and biases of the researcher have a greater potential for affecting the interpretation of data in a qualitative study. Future qualitative studies would benefit from the insights of a collaborative team, involving two or three individuals with different points of view. In this study I was not examining attitudes or questions that were controversial in nature, thus my personal enthusiasm for botany was not a detriment to the study and may have helped keep students involved in the tasks.

Ethnography is not a type of research that is easily replicated. The informal nature of the interviews does not allow for exact duplication. The verbatim record of the field interviews, however, provides an accurate report of how the interviews were conducted and serves as a check on the reliability and validity of the findings. A detailed account of the procedures for data gathering and analysis enables other researchers to critically review the study.

Time and funds are the major limiting factors in qualitative research. To explore all the questions posed could take years of research and still leave many questions unanswered. The researcher must make decisions continuously along the way concerning how to limit the number of questions asked and the amount of depth to pursue for each question.

Analysis of the mounds of data is time consuming. Putting the information into a quantifiable form is difficult, and in many cases not possible. The researcher is continuously in the position of having to interpret and draw conclusions from the interviews. Interpretation can differ greatly between researchers. However, this problem is not unique to qualitative research but is a constant concern of all human studies. This report will enable other researchers to review the data for possible alternative insights.

I used enumeration as supporting evidence of the presence of specific trends in the data. It should be emphasized here that the numerical data can only be used in a very general way for making comparisons. As I did not know what I was going to count prior to collecting the data and as much of the data were obtained from unstructured interviews, the enumeration cannot be used in a

comparative statistical analysis. Nonetheless, counting the frequencies of specific events enabled me to determine what trends were common enough to be worth reporting.

Some problems encountered in the data gathering tasks should be mentioned here. In the field interviews, I did not stick to a rigid questioning format, nor did I intend to do so. This had both benefits and drawbacks. It enabled me to examine a wide variety of questions, but resulted in inconsistent questioning between informants, and sparseness of detail on some topics. Nonetheless, the field observations provided insights into various aspects of children's conceptions that could not have been uncovered with other more structured tasks.

More consistency was needed in administering the structured tasks. For example, in the sorting task I was inconsistent about asking for the "most typical" and "least typical" examples, and so did not obtain as much data from this task as was possible. Also, I did not think to ask the informants to re-sort the photographs into different categories. This would have been very useful in examining overlapping boundaries between categories and in determining informants abilities to identify all the members of certain groups of plants such as cacti.

As this was the first time I had worked with concept maps, the exercise was largely experimental. In the future, it would be preferable to have each student make maps of the same concepts. Several informants stated that they had used the mapping technique in class. These informants tended to put more detail in their maps than those who had not used the technique previously. The ease with which most of the informants picked up the task speaks well for the potential of using concept maps in elementary classrooms. For research purposes, however, the technique may have limited value unless the researcher has time to better train each student in the task prior to collecting data.

Implications for Researchers and Educators

The results of this study have significance for science education researchers, curriculum developers, and classroom science teachers. Cognitive anthropologists, educational psychologists, and others who are interested in theories of meaning and cognition or the study of cultural linguistic development will also find this study useful.

Researchers interested in how people organize knowledge will want to look at the evidence of the use of prototypes in the classification of plants. Examples of prototypes with and without extension were given. Assertions have been made concerning differential salience of categories and the development of residual categories.

The following summarizes my suggestions for future research questions. Recommendations for changes in science curricula have also been included. The data in this study point to some critical problems in school curricula.

The study has provided data on children's folk categories that will be useful for comparison with children in different cultures. Previous researchers have found the generic level of abstraction to

be basic for people in small-scale rural societies, but suggested that the life form would become salient in urban societies. The current study indicates that children in large-scale urban societies prefer generic names over more abstract names for plants even when suprageneric names have become nearly as common in the language. Thus it seems that the generic level remains psychologically basic even when knowledge of generic names is lost. Further studies are needed with both children and adults to discover whether the trends found in this study occur in urban cultures in other countries.

That generic names were preferred by the children has implications for science curriculum development. The text used by these informants relied heavily on levels of naming more abstract than the generic. Abstract categories such as monocot and dicot were introduced in the fourth grade while the concepts of genus and species (the least abstract levels of the scientific classification scheme) were not mentioned before the seventh grade.

The data from this study indicate that the elementary science student should be introduced to the concepts of genus and family (and probably species) before the more abstract levels of the classification hierarchy. The abstract concepts of monocot and dicot probably should be omitted from elementary school science.

It is apparent that student concerns influence how they respond to questions. Teachers need to be aware of the concerns of their students. Coping strategies students use to avoid admitting ignorance or being wrong suggest a need to examine teacher expectations. Student concerns suggest that children are discouraged from admitting ignorance or expressing wrong answers. The following questions are posed for further study: What interactions occur between teachers and students in the classroom that result in or perpetuate these student concerns? Is there a relationship between student success or failure and these concerns? Are these concerns more troubling for certain populations (based on gender, ethnicity, rural or urban background, achievement test scores or other indicators of school achievement)? In what ways can teachers help students deal with these concerns?

I suspect that when students are encouraged to express their inferences, whether right or wrong, they are being encouraged to participate in the scientific process. Further study is needed to evaluate what happens in a classroom in which students are encouraged to admit what they do not know and to express and compare their inferences with other students.

Further research is needed on the importance of outdoor play or rural background on learning about plants. What other factors might influence student performance in either naming plants or defining categories? Achievement tests need to be evaluated to determine what aspects of student abilities (e.g., process skills) may have been overlooked.

When planning botany curricula for elementary schools, science educators need to take into account the natural abilities of children to classify plants. Children's natural skills in classification and observation need to be encouraged and developed in elementary school science.

Because students use many botanical terms that are found in the text, teachers may assume that the children share the same meanings for those terms that the teacher or text do. That assumption may be erroneous. Teachers and textbooks will have to address the differences between folk knowledge and scientific knowledge in teaching plant classification and other botanical concepts.

In the discussion of classification schemes, the suggestion was made that teachers use the students' folk classification schemes as tools for talking about changing models and for comparison with the scientific classification scheme. Research is needed to find out the effectiveness of this type of technique.

The textbooks tended to present plant categories as though they were clearly defined and unambiguously bounded. Teachers need to know that is a false assumption. The problems of overlap encountered with the students' folk categories reflect the reality that the separation of plants into categories based on overall form or unstable or subjective criteria is artificial and arbitrary. Scientific classification schemes attempt to alleviate extreme boundary overlap by using structural criteria that does not vary seasonally and that is perpetuated from one plant generation to the next [Note: the ability to readily analyze the DNA of plant species did not exist when this report was written. Since 1990, plant DNA analysis has revolutionized scientific classification]. Even the scientific scheme, however, has some boundary overlap and is a human (not divinely ordained) invention and therefore not fully reflective of the continuity found in nature. Teachers need to expose students to the idea that there are many ways to classify objects and that classification schemes are models that represent theories rather than proven facts about relationships between plants.

When teaching botany, teachers need to be aware of the child's polysemantic use of the term plants. In examining various polysemantic terms, Werner (1985) argued that when the context is not specified, people tend to assume the meaning that is at the lowest level of abstraction. Werner mentioned, for example, that when one hears the word man, the tendency is to assume that the speaker is referring to a male rather than to people in general. In this research, it was evident that the children tended to think of the term plants at the lowest level of meaning, in reference to herbaceous plants, rather than at the more abstract level that includes trees.

The textbook analysis has indicated some critical areas for needed change in textbooks. Specific suggestions have been made throughout the textbook analysis, with recommendations on what concepts should be eliminated, modified, or added to the elementary text. In summary, it has been suggested that a number of the abstract concepts presented in the elementary texts be postponed or greatly modified until seventh grade, high school, or perhaps even college biology.

The data indicate that children remember best the names of plants for which they know the uses. Information on human uses of plants should be a major part of botany study in every grade of elementary school. I make the following assertions and invite research on them: learning about human uses of native plants will be a strong motivator for children to learn names for plants; knowing the names for familiar plants can be a strong motivator for learning other botanical

concepts.

The amount of material teachers feel compelled to cover each year can be greatly reduced by omitting unneeded redundancy in the texts and reducing the amount of scientific vocabulary. Textbook authors need to pay much closer attention to how they develop concepts in text, taking into account research on the cognitive development of young children. Research is needed to determine whether or not children in elementary school can understand new concepts that are presented with the degree of complexity common to the texts. Textbook writers must make interrelationships between concepts explicit, use vocabulary in various contexts, and provide adequate and diverse visual and verbal examples of concepts. Text must be reviewed by experts in each science area to eliminate false and misleading statements. Regional supplements and field guides are needed to enable children to relate botanical concepts to familiar plants.

Indeed, this researcher would like to see less reliance on the textbook in elementary science. In lower elementary grades, a science textbook may be totally unnecessary. For example, the botany related text could be replaced with children's stories about human uses of plants and regional field guides and keys to local plants.

This research suggests that hands-on experiential science is critical to the study of botany. Photographs of familiar plants would also be a useful addition to the classroom study of botany. As mentioned above, outdoor play may be an important factor in children's abilities to identify or classify plants. Children's misconceptions and lack of knowledge about the parts of plants can probably be altered by guided field and laboratory experiences with flowers and leaves in their diverse forms.

In the summary of the textbook review, recommendations were made about how to assist students in overcoming their misconceptions and lack of knowledge about the names and functions of flowers, leaves, buds, fruit. Research is needed to determine the effectiveness of various types of guided field and laboratory experiences in eliminating these misconceptions.

Misconceptions about flowers and leaves may be related to misconceptions about reproduction and photosynthesis. If so, then hands-on experiences with plants may be absolutely essential in elementary school science. Research is needed to determine whether or not the elimination of misconceptions about concrete botanical concepts will enable students to better understand related abstract botanical concepts.

The researcher reiterates the NSTA (1982a) recommendation that in grades one through four, 50-75% of science instruction should involve the development of science process skills. Hands-on science activities should be designed to allow students to manipulate plants and spend a lot of time making observations and expressing their inferences about what they have observed. The outdoors is a natural laboratory and should be used as such.

Although numerous changes to the elementary science textbooks have been suggested, the question might be asked, is it the responsibility of the publisher to produce books in line with the

research on effective education? Certainly the publisher has a certain amount of responsibility in that area. But the publishers' goal is to produce what will sell. Clearly, school districts are buying a number of textbooks that do not appropriately address the goals of science education. How can this trend be altered? The researcher suggests that teachers must be educated concerning the deficiencies in science textbooks, they must learn how to critically evaluate their own textbooks, and they must become involved with the textbook adoption process.

Will change in the content of the text result in effective changes in classroom teaching? The fact that the science textbook has become the main resource used by many science teachers suggests that changes in the text will have an impact on what teachers do in the classroom. Nonetheless, changing the text is not adequate to bring about all changes needed in the classroom. The question remains of how to get teachers to use more hands-on science and how to get teachers to make the changes recommended by this and other educational research.

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