A Longitudinal Study of Alternative Frameworks in School Biology

by

Margaret Paterson Young

submitted for the degree of

M.Sc. (Science Education)

at

Science Education Research Group, Faculty of Science, Glasgow University.

November 1986

Acknowledgements

Thanks are due to the following people:-

Dr. A.H. Johnstone for his guidance, help and encouragement, as supervisor of the project.

Dr. I.W. Pinkerton for his continual encouragement.

Maureen Johnston for typing of thesis.

George W. Mills for printing of thesis.

Pupils of classes P.3 - P.7 and teachers from the following schools:-

Golfhill P. School, Airdrie

Kirkton P. School, Carluke

Crawforddyke P. School, Carluke

Law P. School, Law, Carluke

Lamington P. School, Lamington

Berryhill P. School, Wishaw.

The following children for participation in the Pilot Study:-

Barnaby Brown

Benedict Brown

Lionel Brown

Wendy McCormack

Dudley McCormack

Jane Dunbar

Rhonda

Scott

Derek

Ewan Downie

Kathleen Downie

Katherine

Peter-James

Sarah McIlree

Philip McIree

Judith McIlree

Clair

Andrew

Stephen

CONTENTS

Summary

The following research study is concerned with childrens' natural ideas and beliefs in the area of the life concept. Previous research work has shown that many children form their own theories to explain things in the world around them. These mini-theories are called alternative frameworks because they may differ from the accepted scientific theory. They are very persistent and they may interfere with school learning.

This study was carried out in order to discover whether children have alternative frameworks in the area of the life concept and to find out if children of different ages are able to classify correctly certain objects as living or non-living. The attributes of life which children give to a living thing were also examined.

Firstly, a Pilot Study was carried out to find out if there were any erroneous ideas present in childrens' minds. Four groups of children, whose ages ranged from 5 to 10 years were allowed to discuss a variety of objects in an informal way; they had to say whether each object was living or not living and to give reasons for their decision. From this study it emerged that alternative frameworks were present at all age levels and that some children believed that certain non-living objects were living because of the attributes which they possessed.

The main part of the research, the School Study, involved about 800 pupils in the age range 7 to 11 years from six Primary schools. A work-sheet was designed for the purpose of obtaining information from the pupils. It contained a box-grid with 16 objects, some questions relating to the grid, one question about microscopic things and one about attributes. Several children, mainly pupils aged 7, were also interviewed and their answers were noted.

The results showed that nearly every child is certain that animals are living and most children also believe that plants and trees are living. Many children were not sure that mould is living and they had difficulty in suggesting life attributes for it. Only a small percentage of children believe that a potato and fruit are living and many children included them in the category "not living now but came from a living thing"; many children, even at age 11, do not have a concept of dormant life.

Many children, the highest percentage being at age 7, included crystals as being living. Their reasons were that crystals grow and look like plants. 50% of children at ages 8,9 and 10 still believe that the sun is livng because it moves and gives light. Similarly, some children at every age level believe that a flame is living because it possesses heat and movement. About 16% of children at every age level included a battery as being living and a few children, aged 7 and under, believed that a clock is living because it "goes" or "works". Many children were able to place meat in the correct category "not living now, but came from a living thing". However, a high percentage of children, except at age 11, do not know the origin of bread, leather or sugar.

50% of children at all age levels have the erroneous belief that the particles inside a substance are living, probably because of their movement. In addition, many children do not class microscopic plants as being living. When asked to describe a living thing, most children do not give any of the seven accepted attributes of living things except movement. "Eating" and "Senses" were included fairly frequently. Most children, even at age 11, do not give the attributes reproduction, breathing, growing or excretion. Instead, they include many attributes which pertain to a large, furry animal.

If large numbers of children aged 11 have these alternative frameworks, then they are not ready to proceed with a Biology course at Secondary school. They will view teaching about living things and about attributes with surprise and they may not accommodate the new information into their minds. They may simply rote-learn it in order to pass exams. Teachers need to be made aware that alternative frameworks exist in many school-children and the teachers should try to expose these erroneous beliefs before presenting pupils with the correct facts. Pupils in Secondary school should be tested regularly using Diagnostic testing to find out whether they are still retaining any alternative frameworks, before they receive formal instruction in Biology. Then learning will be meaningful and facts will be remembered.

Children entering Secondary school may have incorrect ideas about living things and the attributes of life. As a result, many children class certain living things as non-living and certain non-living things as living, even at age 11. Obviously they are not able to begin studying Biology if they are still retaining these erroneous beliefs. Pupils are then not ready to learn new facts in School biology because they do not have a complete understanding of living things and they have an undeveloped concept of life.

Many children are also unfamiliar with the seven attributes of living things. They form their own sets of attributes most of which apply only to large, furry animals. When they are taught the correct attributes, many children will view these with surprise. Consequently they will have difficulty in accepting this new piece of learning and in remembering the seven attributes. Many children store pieces of knowledge, which are taught to them in school, and keep them separate from their own personal ideas and beliefs.

Biology teachers should be aware of this conflict and of the erroneous ideas in pupils' minds, and they should be prepared to adjust their teaching accordingly. For example, children know very little about plants and other forms of life, apart from animals and insects, yet they will suddenly be presented with teaching about these things and be expected to understand all of it. Primary school teachers need to be aware of the problem too. Teachers of P.6 and P.7 classes could perhaps try to expose some of the erroneous ideas and gradually introduce the correct facts to pupils.

I became aware of Primary school childrens' ideas and beliefs about living things and the natural world from being involved with groups of children at different times. During a period of employment with Glasgow Parks Department on a Nature Education project, which involved working in several Primary schools, I became interested in childrens' views of the living world and I realised the limited extent of their knowledge.

Later, while teaching elementary Science to three children in a Home Education Group, I was able to perceive childrens' ideas in more detail and to question the children and discuss their ideas with them. So I thought that it would be useful to make a proper study of Primary childrens' views of living things, by interviewing a large number of children, and, in this way, to find out if any of them had a complete concept of life.

Some studies have already been carried out on the life concept, firstly by Jean Piaget (90) and more recently in Israel (58), Australia (59), and New Zealand (93). Not all of these were concerned with children under age 11. In Scotland, one recent study has included 'living things' as a pre-requisite concept for learning certain concepts in Secondary school (4).

There have also been studies on alternative frameworks. These are erroneous theories which are built up by children to explain things and which are often retained throughout adolescence and adulthood unless they are proved by the person to be false (1,11). Children could form alternative frameworks relating to living things and attributes of life: this could lead them to class a non-living thing as being living and vice versa. There have been very few studies on biological alternative frameworks, except some studies concerned with Plant Biology in pupils from age 11 to 16 (4,39,19). Most of the studies are concerned with adolescents or college students and not with Primary children.

So there follows a study of childrens' ideas and beliefs about living things at different age levels, mainly in the age range 7 to 11.

CHAPTER 1

Survey of Previous Research Studies

What are alternative frameworks?

Alternative frameworks are childrens' or adults' informal theories (1). They concern the substance of the actual beliefs and concepts held by students (2) and are autonomous frameworks for conceptualising experience of the physical world (3,4). They are given various descriptions e.g. naive conceptions or well-formed notions (5), children's science (6), and mini-theories (7). They are derived before formal instruction (3,4,5,6,8,9,10).

They differ from the accepted scientific theory, or are less refined, hence the name "alternative " (1). They may not therefore be wrong but are partial and limited in scope (11,12), and not as inclusive as the scientific view (11). They are described as "confused and inadequate" (13,14), "deficient" (10), "showing lack of coordination and consistency (5).

The Conflict: Child versus Scientist

Since the accepted scientific theory may be counter-intuitive with pupils' beliefs, a conflict arises between the two (11,15,16). Childrens' views of the world are not necessarily scientists' views (12,17), and this produces confusion. The vast discrepancy between them is revealed in school learning: alternative frameworks may be at variance with theories the teacher wishes to develop (11,18,5). Simpson and Arnold found that pupils' concepts of digestion and respiration were different from those of teachers in nearly every 'O' Grade class (19). To 16 to 18 year olds, physics exists in an idealized world unrelated to the real world (20). Solomon views pupils as thinking in two very different domains - everyday, out-of-school notions and scientific knowledge (21).

The child's view appears more sensible and logical to him than the scientist's view (22,6). Children find abstract reasoning difficult and latch on to a number of explanations and show no coherence of thought (6). They tend not to use precision in thinking (23,24), but look for surprise and the unpredictable, whereas total surprise is suspect in real research (25). Strike and Posner point out that students are not recapitulating scientific history in their discoveries(26).Solomon states that they are untrained in the formulation of a hypothesis (25).

Alternative frameworks as true hypotheses

However, alternative frameworks also have a positive sense. They are described as true hypotheses or theories with a strong, concrete base (4,1) or elaborate constructions of theory and explanation (19). Driver states that they indicate intelligent and rational thought (1); they should be used to foster scientific thinking (4). They exemplify the plural nature of scientific pursuit, with competing interpretations and conceptions of events, and lead to experimental design (11). Pupils, like scientists, draw on available images and words to form theories (10).

Construction of false theories or over-generalization of limited ones are seen by some researchers as productive processes; over-generalization may be implicit in the young child's behaviour but could be intentional in the scientist's (27). Donaldson points out that spontaneous reasoning occurs in children, even under age five, and the gap between children and adults is less than that claimed (28). Driver and Erickson refer to the "Student as Scientist" metaphor which allows pupils to explore new ideas and construct their own knowledge (29). Alternative frameworks have internal coherence and widespread use (30). Events they describe have clear and obvious outcomes and they may be called upon in a new situation or to generate a prediction (7,31).

There is some similarity and parallel between childrens' alternative frameworks and early scientific theories (1,26). Some examples include Aristotelian and Einsteinian conceptions of motion, pre-Galilean ideas of dynamics, students' beliefs reminiscent of the mediaeval theory of impetus, and explanations about light which are similar to early Pythagorean ideas (5,3,8,32,33). It is notable that beliefs seem to govern the progress of scientists' enquiries throughout history, rather than empirical results (11,25).

How Alternative frameworks arise

Alternative frameworks arise from three main sources:-

1) Experience

2) Intuition

3) Language

1) Experience

They arise from childrens' personal, everyday experiences which they attempt to make sense of for themselves (1,3,6,17). They are developed to explain events and observations (4,5,31), and to satisfy the demands of children to understand and make predictions about phenomena important to them (17,19).

According to Piaget, a child up to age seven is influenced by his perceptions which can be misleading, and knowledge is constructed through interaction with the environment: children arrive at knowledge by different routes depending on experiences (34). Children can often have advanced notions related to specific experiences in their lives (35). West says a mini-theory is a remnant from experience (10).

The origin of alternative frameworks could be kinaesthetic sense experience, i.e. relating to a sense of movement (34,36). They are a person's imaginative efforts to describe their physical world (5,11,30). Children reason analogically, relating new, unfamiliar events with familiar ones (1). They increase knowledge by mixing relevant with irrelevant (9).

2) Intuition

Intuition, which depends on past experience and knowledge, brings the first ideas to a child which are then built up by means of logical relationships (1,34). A child experiences flashes of insight which are often unstable and fitful, then he constructs a logical argument to confirm his intuition (34). Nussbaum says that a child is dominated by his own intuition (9). Intuitive notions, especially metaphysical commitments, form a prior set of conceptions (18,37). Pupils have intuitive versions of concepts e.g. heat and entropy (2,15). Viennot refers to "intuitive physics" (8).

Alternative frameworks arise in an intuitive way from a child's anthropocentric view of the world where he focuses on his own needs and abilities (9,14,30). Childrens' first conceptions are egocentric (20,35). Solomon points out that most children resist the overt suggestion and substitute their own (25). Many alternative explanations given by children are naturalistic, i.e. non-mechanical and relating to needs; for example, about heredity, water intake in plants, inherited characteristics, and properties of gases (14,38,39,17,13).

3) Language

Another source of alternative frameworks is language (6,36,40). Teachers' use and pupils' understanding of language are of prime importance in education (41). Communication difficulties occur between teacher and pupil when each enters dialogue with different interpretive frames (42,43). Donaldson showed how a teacher can look on the world from his own positon and fail to realise that a child interprets words differently and sees things in a different way (28).

a) How a child interprets words

A child can misunderstand what the teacher says and can develop his own idea. Instruction often cannot be correctly interpreted and more information is needed on things the child is unfamiliar with (4,28,39). Solomon says that children meet an impasse when they encounter a word or phrase unfamiliar to them (25). They may have a clear idea of what is said, but it does not make sense or accord with their experience (18). The meaning of a word is not its definition, but all the connections to things the child knows (44).

A child interprets a whole situation, not merely words in isolation and his interpretation is influenced by context, expectations and perceptual factors. He may make a correct interpretation on one occasion but not necessarily on another (28). Bernstein found that ways of viewing the world amongst middle-class and working-class children differed largely as a result of form of speech typically employed by their particular sub-culture (45). It is known that children from more privileged and literate homes pay more attention to words (28). This could either encourage or prevent formation of alternative frameworks.

It is possible that they form at an early age. By age five a child learns to weigh possible interpretations using thought and language (28). Chomsky's theory of a language acquisition device, innate in humans and tuned to key features of human language, means that a child formulates rules for himself, not necessarily imitating adults; he may begin correctly then adopt an erroneous form (28). One function of language is to make sense of experience (44). This gives scope for development of intuitive frameworks. However, Donaldson reminds us that the ability of a pre-school child to use language is in advance of his ability to understand (28).

b) Everyday and scientific meanings

Words with an everyday meaning and a scientific meaning, e.g. animal, sugar, lead to

formation of alternative frameworks (6,10), and cause difficulties in understanding (15,46,47). Pupils meet these words in text-books, oral communication and exam questions (48,49). Many key words in science are interpreted by children in their own framework of ideas different to that assumed by teachers (50). Ross and Sutton found that few Secondary pupils spontaneously made scientific associations to everyday words like "growth" (46).

Unscientific ideas are reinforced by everyday talk e.g. about energy, and old meanings do not easily die (47). Oxygen is believed by many to be the most common gas in air, because the term "oxygen" receives a lot of verbal stress in people's experience (51).

Simpson and Arnold say that prevention of alternative frameworks is better than cure (19). Pupils need to know the scientific meanings of words and they should receive help in building a useful vocabulary (48,52). Use of imprecise terminology and simple terms e.g. "sugar" in osmosis must be avoided (39). Idiosyncratic variations of definitions and ideas should be kept to a minimum to enable clear communication (19,39). Animistic elements in teaching can mislead pupils (9). Some words in Biology have multiple meanings e.g. animal, adaptation: children should be aware of the different meanings and different uses of a term by authors (6,53). Confusion may lead to development of naturalistic and erroneous ideas (14,53,54). So alternative frameworks may arise during formal instruction, or informally via books or television.

Misconceptions

Misconceptions, which differ from alternative frameworks, are errors of fact or wrong ideas about defined concepts which relate to content met at school (1,11,55). They are the result of incorrect assimilation of school learning, especially where descriptions are misleading (1,55). They are clear in pupils' minds and interfere with learning (39). They can occur through assimilation of taught material into pupils' alternative frameworks (55); these are then both contaminated and reinforced (5), e.g. food-growth and energy-movement associations (55). Alternative frameworks are more intractable than misconceptions which occur in relative isolation from other facts and can be corrected (3).

Driver sees a continuum existing between the two extremes of alternative frameworks and misconceptions (3). They do have similarities and some authors seem to be describing alternative frameworks when they speak of misconceptions, e.g. erroneous notions occurring with high frequency, intuitive misconceptions in physics (22,20). Also they are found among

science and non-science students (22,51). Solomon speaks of misconceptions which are deeply rooted in society and at odds with the scientific explanation (21). She does not consider childrens' out-of-school ideas about energy as alternative frameworks, but as non-scientific, socially acquired meanings (47).

Common Patterns in Alternative Frameworks

There is evidence for common and identifiable patterns in alternative frameworks. Similar notions have been found in children in different countries, even where there are language and curricular differences (1,2,56). In both American and Israeli children the same strange notions about the earth, and about living things, were found (57,43,58,59). Champagne et al said there were common elements in the naive conceptions, giving a prototypical macroschema (5).

Others refer to alternative frameworks as generalised, non-individual descriptions (60). Intuitive physics could represent a way of thinking in nearly every person (8,32). Common frameworks, in response to questions, have been found, even in different contexts, and the frequency of frameworks at a particular age remained the same (56).

The same alternative frameworks are found at different age levels, for example beliefs about heat, about inheritance and about the earth, in children aged from seven to thirteen (2,17,57). Simpson and Arnold found that many Secondary pupils had retained the Primary school ideas about living things and about plants obtaining food via their roots (55). It appears that High school students retain old ideas for as long as possible (61).

However, there may be some alternative frameworks which are unique to an individual. Conceptual knowledge is idiosyncratic (5,19). It is a reflection of the world to an individual (10). It is thought that different individuals construct a framework from the same information and often consider that theirs is the only reasonable conception (18).

Stability of alternative frameworks

Alternative frameworks are deep-seated and resistant to change (11). They are described as persistent or robust or resilient (5,8,10). They have tenacity in the face of teaching and outlive the teaching and experimental evidence that contradict them (30,5,8,61).

Not every researcher emphasises the stability of alternative frameworks: it may depend on the particular framework. Driver says that some are transitory (11). Others point out that childrens' views may change as they get older (12,50). However, they may become

increasingly different from the scientific view (6). It was found that, over a three year period, some pupils retained the same framework about "pressure", but more usually they changed (56). Hewson also emphasised the dynamic nature of frameworks (18).

Alternative frameworks and School Learning

Since alternative frameworks are so stable, what happens during school learning? A child is not 'tabula rasa' with a mind like a blank tablet, but he has a prior set of conceptions (21,24,57). Alternative frameworks are a possible barrier to science learning (5,10,19,55); they make concepts difficult to grasp, especially those involving invisible entities (13). Even after teaching, pupils' frameworks affect their thinking and have a significant influence on what they learn (11,19,24,55) Ausubel said, "the most important single factor influencing learning is what the learner knows already" (62).

a) Co-existence

Alternative frameworks may simply co-exist with those constructed around school learning (36,55). Pupils layer school knowledge separately from real-world knowledge and do not relate the two (46,47,56). They operate whichever system seems most relevant (15). School experiences interact with pupils' ideas (26,50,63). Karmiloff-Smith and Inhelder found that children initially produced an independent theory to cover anomalies, and retained their old theory in situations where it was applicable (27).

Pupils may not incorporate a taught explanation into their existing pre-conceptions (9,39), especially parts which conflict with their beliefs (5). They do not always apply a taught idea either(15,54); they revert to and trust their intuitions when they meet a new task, even when they seem to have understood an idea (11). The scientific viewpoint may be used in an exam, but it is not the way the pupil actually thinks about the concept (6,24).

Terms are often rote-learned and recalled without understanding (39). However Smith points out that formalised writing in science text-books leads pupils to believe their own thinking does not count, so they regurgitate someone else's material (64). Children can use words even in the correct context, and often give teachers an exaggerated notion of their understanding (6,51,65,66). A student may believe he has understanding, but have a different interpretation to that intended e.g. a car has 'life' (20).

b) In the laboratory

Alternative frameworks also affect pupils in laboratory classes by hindering experimentation. They influence and focus future observations, so that expectations take priority over logical thought, and pupils see what they expect to see (11).

Pupils become confused when they see that their prediction is wrong and the result unexpected (5,25). If observations cannot be assimilated into their previous framework, pupils will not be able to understand their data (11).

Frameworks affect interpretation of phenomena (16). For example, ideas about light affected drawings, where pupils used curved lines to depict light rays (11). Pupils often comment on a feature salient to them (28). Frameworks may cause neglect of relevant features (11): this would be important in Biology, especially with microscope work. They also render problems as pointless and unintelligible to pupils from their frames of reference (16).

Abandoning Alternative Frameworks

Is it possible to help a pupil to abandon his alternative framework? In the revolutionary view of conceptual development a child holds alternative frameworks or mini-theories. When he meets a new phenomenon, conceptual change means abandoning one framework and accepting another (10). From an evolutionary viewpoint a child relates new observations to his existing knowledge, altering it gradually to achieve consistency (10,61).

The revolutionary view involves a series of changes, which are acts of cognitive accommodation (9,37). Accommodation occurs when an individual modifies a central or basic concept and is a large-scale change (26). The existing alternative framework must first be addressed (18); the student must have dissatisfaction with it, recognise it as inadequate, and any anomalies in it must be emphasised (18,26), The child needs access to a new and better idea to replace the old one (18,26). The new idea must be plausible, intelligible and preferable to the old one (37). Lovell states that, for accommodation to occur, there has to be an active search for all points of similarity between new and existing ideas (34). Replacing the old idea is called "exchange" (63).

It is desirable to replace an alternative framework with a correct idea, and this is not always easy because of the extensive network of connections in pupils' knowledge (19). Nussbaum says that it involves a major cognitive revolution similar to that experienced by past scientists when replacing their conceptions (9). Several researchers describe the

replacement as an imaginative or intellectual "leap" of abandoning an alternative framework which was "working well" (3,61,11). Carefully thought-out arguments are required to persuade pupils to abandon their alternative frameworks (19).

Where new material is not plausible it cannot be meaningfully incorporated (18). Then rote-learning occurs which is not meaningful (4,38,42,61,62). Pupils have to make or re-construct the meaning of an idea for themselves (41). If the student's meaning changes to the scientific meaning before formal instruction, then learning is more meaningful (20). Experiences alone do not help pupils to reconstruct an alternative view (11,25). Metaphors have a central role in bridging the gap between old and new knowledge, and accommodation can be seen as a mechanism underlying function of metaphor (31,67). Metaphors play a significant part in scientific advance and provide an element of make-believe (31).

Counter-examples and conflicting evidence may not be sufficient to cause change and could produce confusion (11,26,42). However, Driver points out that the conflict between reality and students' beliefs may start the slow process of change (42). Cognitive conflict is unacceptable to people; it is uncomfortable to hold two inconsistent beliefs (28). Strike and Posner say that cognitive conflict can lead to accommodation (26). This can be made use of in the classroom. Students are assisted to explore and discuss their alternative frameworks, before being exposed to conflicting evidence. Then they restructure their frameworks accordingly, or invent new ones (68). Champagne et al refer to this method as Ideational confrontation (5).

Exposure of alternative frameworks

It is clear that alternative frameworks do have an effect on what is learned at school, and teachers should be aware of them. Simpson and Arnold found that Biology teachers did not appreciate the nature, stability and extent of the frameworks in pupils, and the existence of stable concepts was taken for granted (55,69,70). Parts of the course which teachers thought pupils understood best were the parts where pupil performance was poorest (4). They point out that concepts which are wrong, but meaningful to the learner, may escape detection (70).

Other researchers point out that childrens' views and pre-conceptions need to be identified (6,12); teachers should learn to detect misconceptions in written work also (9). Biology teachers should be aware of childrens' conceptions of life in order to explain and avoid ambiguities (58).

Diagnostic tests show the presence or absence of alternative frameworks (19,38,39).

The tests give insight into pupils' thought patterns (71). Their long-term value is in helping teachers to select strategies appropriate to pupils' understanding (39). So they are both a teaching and a learning aid. Criterion-referenced tests merely define non-attainment and do not regard causes underlying it (19).

Discussion can also be used to expose alternative frameworks as it includes wrong approaches to a problem and childish views; it can, for example, arise naturally out of a pupil's public question (25,72). Pupils should make their personal ideas public so that they can be challenged (19,73). They should be given opportunity to reconsider and test their ideas (5,12).

Research into alternative frameworks

a) Aims

The intentions of research into alternative frameworks are to identify frameworks, to describe their nature and incidence, and to communicate this information to teachers and curriculum designers. Areas of study include how students make sense of the physical and natural world and the use of concept words which have everyday meanings.

Driver states that it is important to consider pupils' own ideas, i.e. what they know, which involves their conceptual rather than logical structures (1). Such studies are Ideographic studies where childrens' views are analysed without assessment against a defined system (3). Green et al comment that characterizing the content of peoples' belief systems should be a major current goal in cognitive science (32).

b) Methods

Studies of alternative frameworks involve student interviews which are often tape-recorded (11,14,57), as well as observations of pupils (13,42), or use of pupils' drawings (32,57). Written tests are also employed (4,54,56). In the "Interview about Instances " method pupils distinguish between instances and non-instances and can discuss reasons for categorizing (20,43,65). Erickson compiled conceptual inventories for each pupil to represent a pattern of their beliefs (2).

The studies are not an end-point in themselves but are to lead to teaching methods which take seriously the learners' perspectives (1,11,14). They should help in understanding some of the sources of pupils' potential difficulties (9,17). Teaching strategies should capitalise on the existence of different alternative frameworks (4,10). They should be built upon or confronted, but not ignored (6,12); they can be made use of to avoid difficulties in

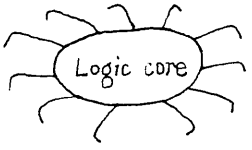
understanding (9).

Concepts

a) Definition of a concept

A concept, according to Lovell and Klausmeier et al, is ordered information about the properties of objects or events, that enables any thing or class to be differentiated from and related to other things or classes (34,74). It is both a mental construct of the individual and the societally-accepted meaning of the words expressing it (29,75).

Concepts are described by critical attributes (75). A concept has a logic core, which is an abstract structure of properties, and a name. The Bur model (Diag.1) shows the logic core and the associative frameworks which attach to life situations and show a person's concept development in time (76).



Diag. 1

b) Conceptual development

Concepts are not fixed structures: they continuously change as people develop and learn (10). Concept development proceeds from perception to abstraction to generalization, until the jump from percept to concept occurs in the mind and is aided by memories and images (34). Then the child forms relationships between things (28). A concept does not develop in all situations and in all media at the same age, contrary to Piaget's belief (5,11,34). The rate of development depends on brain mechanisms, the child's motivation, the cultural milieu including the classroom, and on varying psychological traits (14,24).

c) Pre-requisite concepts

Pre-requisite concepts are those which must be acquired in preparation for understanding more complex concepts (65,69,70). Gagné stated that all the relevant pre-requisite skills must be possessed by the learner if any complex skill is to be acquired (79).Pupils must incorporate basic pre-requisite concepts into their understanding so that new ideas can be related to existing ones (11,31,77,78).Arnold and Simpson found that O Grade pupils did not have the pre-requisite concepts they were assumed to have, due to indadequacies in previous science courses(39).

d) Concrete and formal concepts

Concrete concepts are those which name classes or entities for which there are perceptible instances or which have easily perceived defining attributes, e.g. animal, plant. Formal concepts do not have perceptible instances or perceptible defining attributes, e.g.

heredity, osmosis (79,80). They are called abstract or defined concepts, learned by definition (79).

The majority of science concepts taught at Secondary school and College level are formal (81). In Biology they involve controls and more than one variable (82). Some were learned previously as concrete concepts, especially in Primary School (83): a child can relate abstract ideas to analogous concrete situations (25,34,84). Concrete concepts with simple mechanistic explanations only require concrete thinking, but formal reasoning is required for understanding formal concepts (78,82,85).

Piaget's theory states that these processes of thinking are characteristic of certain stages of development i.e. concrete operational thought develops up to age eleven, then formal operational thought begins (86). Richards found that concrete concepts dominate a child's perceptions up to age ten, then there is an increase in scientific concepts held, due to instruction (66).

e) Concept understanding

Ability to classify is a key component of concept understanding (74); it is based on formation of precise concepts and relationships between them (20,87). Klausmeier specified four levels of concept understanding, modified by Simpson & Arnold as follows:-

1) Ability to use the word correctly or respond to it in conversation.
2) Ability to give spontaneously examples of the concept.
3) Ability to assign to its class examples and non-examples of the concept.
4) Ability to give verbally some basis for classification.
5) Ability to classify examples and non-examples, and show full knowledge of all defining attributes (69).

Where two concepts are similar and share some common features, learning of one process interferes with learning of another e.g. photosynthesis and respiration, or diffusion and osmosis (4). If pupils apply their knowledge or give examples and non-examples, interference is prevented; it is not likely between rote-learned concepts (4,88).

The Concept of Living Things

a) Defining attributes

The life concept is a concrete concept, but the defining attributes are not all perceptible at once:it can be defined in terms of Klausmeier's levels (4). There has never been a single

definition of criteria for the life concept (59). There are the traditional seven characteristics of living things - growth, nutrition, respiration, excretion, locomotion, reproduction and irritability. Brumby adds the biochemical characteristics e.g. D.N.A., glucose and cellular respiration.

b) Development of the concept of life

The concept does not develop suddenly (4). Until the age of four or five, latent animism is integral and implicit, and moving bodies, like guns or boats, inspire animistic expressions. Children do not distinguish things from living beings: they endow things with will, desire and conscious activity (89,90). At age four to six, this disappears and children question as to how far things are alive and conscious (90).

It has been concluded that animistic notions exist among children of all ages (91). Some researchers found that eleven and twelve year old children attributed life to a range of moving objects e.g. sun, fire, hurricane (4,92). Piaget noted children's belief that the sun and moon follow them (90).

c) Movement as a criterion

Piaget found four stages in development of the life concept (91). In the first three, movement is an important criterion, and given by every child. Stage 1, at age six to seven, is where everything which has activity or function is regarded as living; Stage 2, at age eight to nine, is where everything which has movement is living; Stage 3, at age nine to eleven, is where the child identifies life with spontaneous movement alone.

Tamir et al found that movement was the most popular indicator for life, especially with regard to animals and inanimates, used by High School pupils in Israel. Movement of inanimates was, however, viewed differently from that of animals, and pupils did not conceive that the life of the sun, fire or wind was the same as that of a cat or insect (58). This suggests that life has many meanings to children. When tertiary students were asked to give reasons why a child thinks fire is alive, over half of them cited spontaneous movement (59).

d) Other criteria

The same tertiary students also mentioned the criteria growth, warmth and giving of light (59). Fire tends to be non-living to young children but many eleven and twelve year olds consider it to be living (93). Brumby concluded that most adults do not believe that fire is alive in a scientific sense i.e. it does not have the seven characteristics (59).

Tamir et al found that older pupils gradually used movement less as an indicator (58). According to Piaget, the child adds adventitious definitions resulting from chance conversations or words overheard, e.g. " to speak" or "be warm", or "have blood" (90). Criteria for life given by P.7 pupils in Scotland were "move, breath, eat and grow". Many Secondary pupils had retained these Primary school ideas (55); they simply gave these same responses (4).

In Israel, the indicators growth and development were used for embryos, e.g. seeds and eggs, and plants (58). It has been found that animal associations with the concept growth decrease with training, while associations with plants and cell division increase (76). Similarly, growth was associated more with plants by Secondary pupils (46).

Additional criteria given by University students were possession of a brain and cells. Cell structure was used more frequently by University students than by student teachers (43). Absence of cells and organic chemicals were given by tertiary students as reasons why a rock is not alive (59). However, younger pupils show some confusion in these areas. A recent study found that some S.I and S.II pupils did not think that living things, e.g. worm, tree or man, are made of atoms and molecules, but things like crystals and heat are. Some pupils said that water and protein were made of cells (19).

e) Animals and plants

Piaget's fourth stage in development of the concept of life is where life is restricted to animals and plants: 75% of children do not reach this stage before age eleven or twelve (90). Arnold and Simpson point out that ideas about living processes, plants and animals begin to develop in late Primary and early Secondary stages (4). They found that P.5 pupils' concept of life was relatively undeveloped, but all pupils could use the term "living thing" correctly and give examples i.e. Levels 1 and 2 in Klausmeier's method (55).

48% of Israeli pupils viewed plants as having a different kind of life from animals, where ability to move was the indicator. Nearly all the pupils classified animals as living but there was less success with plants (58). 69% of Scottish P.7 pupils classed a plant as living (55). Other characteristics seem to lead to differentiation between plants and animals. Secondary and P.7 pupils' identification of respiration as a process occurring in animals is very strong but in plants is very weak. They equate respiration with breathing; gas exchange in animals is viewed as opposite to that in plants (4). In a study of Nigerian pupils, aged 16 to 18, it was found that they did not understand that plants were capable of sexual reproduction

and they viewed asexual reproduction as being restricted to micro-organisms (78).

Few pupils have a concept of dormant life. However, not many researchers have investigated this. Tamir et al found that about half of the pupils tested, from age nine upwards, classed neither eggs nor seeds as living: life of dormant seeds seemed to be very different from that of germinating seeds (58).

Classification of living and non-living

Arnold and Simpson found that S.I and S.II pupils showed no improvement over P.7 pupils in ability to classify into living and non-living categories. S.IV non-Biology pupils had fewer inclusion errors in the non-living category than S.IV Biology pupils. They suggest that this is due to exposure to the metaphoric view of 'living' both in and outside the classroom (4). Similarly younger children tend to have a more scientific view of the word 'living' than older children (93).

Biological attributes

It has been found that, although children up to age eleven classified items correctly, they had an incomplete understanding and vague notions of 'living' in terms of its associated biological attributes (94,95). Bell found that only 14% of eleven year olds categorized all instances from the scientific viewpoint. She suggested that there may be a scientifc conceptual rationale behind the child's concept: there is often confusion between the scientific characteristics of living things and those of animals (43).

Results are similar for older pupils. Processes of reproduction, excretion, etc. though taught in early Secondary school, are not given as responses by S.I and S.II pupils (4). Levels of responses using biological attributes were found to be still low in S.III and S.IV pupils. Some S.IV pupils had the final concept of living things and gave the biological characteristics feeding, growth, movement and two others. No non-certificate S.IV pupils attained this level (4). Another study showed that Secondary pupils gave attributes in terms of spontaneous generation, respiration and anthropomorphism, even after six years of science (96). Also the majority of 1st year tertiary students had merely rote-learned the biological attributes (59).

It is assumed that pupils have a biologist's concept, but many also have an everyday, restricted concept, and interpret dialogue in terms of everyday use of the word (43). e.g. a battery having 'life'. Childrens' criteria for the concept of animal were 'four legs, large size, terrestrial habitat, noise and possession of fur', resulting in a restricted concept (43,97).

Similarly a plant, to children, is something growning in a garden, but a carrot is not looked on as a plant (97).

Importance of the life concept

The life concept is central to any life science course (58). It is a pre-requisite concept for understanding more complex ones like Photosynthesis (69). It brings together ideas of the needs and characteristics of living things and the concepts of animal and of plant (12). Some authors say that children should understand the unity amongst living things and features in common between plants, animals and embryos (58). Others say that emphasis should be placed on the variety amongst living things (69).

There should be opportunity at Primary school for development of the life concept (12). By age nine or ten, children should know that living things reproduce, grow and require food. By age eleven or twelve, they should know the seven basic life processes and the variety of ways these are carried out (98). An addition to this is the knowldge that all non-living things are made from substances found in the earth (99).

Primary Science and the life concept

A recent study found that few Scottish Primary pupils had followed a formal Primary science course: at most they had done nature study (100). In a cultural study it was found that children learn about life processes from experience and tradition, or from information and the media, not necessarily from school learning (101). Local factors can influence childrens' conceptions of life (12): pupils from farming backgrounds in Israel had more correct ideas (58).

The Primary Science schemes such as "Nuffield Junior Science", "Science 5-13", and "S.C.I.S." in the U.S.A. are concerned more with developing an enquiring attitude than with learning facts, "Science 5-13" has many content-free sections. The idea is that children find out for themselves and concepts develop easily (99). As Solomon suggests, such an unstructured learning programme could be unhelpful (25). With a common content, children receive scientific ideas which act as foundation for future understanding (99). Donaldson points out how the child needs our help, and is not capable of deciding what he should learn (28).

Secondary School

There should be opportunity for further development of the life concept at Secondary school, where childrens' experiences should be extended beyond everyday events (12). The

Primary school ideas e.g. walk, talk, move, breathe, may be logically extended in Secondary school to the biological attributes, and this should prevent rote-learning (69).

Conclusion

Lovell remarks that children are likely to be taught concepts according to the way teachers think they devlop (34). So information on the development of the life concept in children should be of value to teachers. There is little published research on studies of biological conceptual structures in young children, and such studies, it is suggested, would be valuable (14).

CHAPTER 2

The Pilot Study

Aims

The aims of the Pilot Study were to:-

(a) find out childrens' natural and intuitive ideas about living things

(b) discover childrens' reasons for thinking an object is living or not living

(c) see how they relate an object which is not now living to the living thing it came from

(d) look for any changes in childrens' ideas with increasing age.

Procedures

The Pilot Study was carried out between October and the beginning of December 1983. In order to find out the childrens' natural ideas, tests were to becarried out in an informal way and outwith the school situation.

(a) The Tests

Four different groups of children took part on four occasions. The number of children involved was 18,11 boys and 7 girls. Ages ranged from 5 to10 years. Six of the children were known to me before the tests; some children came from the same family.

The tests took place as follows:-

Date	Location	No. of children	Ages
26/10/83	My flat	3 boys	5,8,10.
31/10/83	University crèche	2 girls, 3 boys	6,71/2,73/4,81/2,9
16/11/83	Home of children	3 girls, 3 boys	5,8,81/2,81/2,10,10.
5/12/83	Home of children	2 girls, 2 boys	7,71/2,9,91/2.

(b) The Discussion - Test

A number of objects were laid out randomly on a table in front of the children. The test took the form of an informal discussion with the children; the aim was to allow them to talk freely and argue amongst themselves. An informal and relaxed atmosphere prevailed and the children did most of the talking.

They were allowed to touch the objects and ask questions about them. What they had to decide was whether each object, taken in turn, was living or not living, and they were encouraged to give their reasons for their decision. The objects were not discussed in exactly the same order on each occasion. Following this, discussion continued about some objects

which the children pointed out were not living at present, but had once been living, or had come from a living thing.

The objects used in the tests were as follows. Not all of these objects were used in every test.

Live animal (mouse, gerbil)
Live insect
Pot plant
Moss or Grass
Mould
Cut flowers
Green leaves
Brown leaves
Apple or carrot
Potato
Wild Berries
Cress seeds
Germinating seed
Twig
Cork
Candle
Flame

Feather
Rabbit's tail
Leather
Sugar
Bread
Egg
Stones
Battery
Radio
Crystals
Crystal Garden
Shells
Preserved insects
Alarm clock
Glass of water
Bubbles
Piece of wood
Cone

The children were also asked whether the following are living or not living:-

The sun	The wind
The moon	A tree

Each discussion-test lasted for about one hour and was tape-recorded from start to finish. Later a transcript was made of each recording. The transcripts were then edited to extract the comments which were of importance and interest.

From these discussion-tests, information was gained about

(a) which objects children think are living,

(b) which objects children think are not living or were once living,

(c) how childrens' beliefs and ideas change with increasing age,

(d) how they relate an object which is not living at present, to the living thing it came from.

Results of Pilot Study

Section 1: Results of Discussion-Tests

1) The following table shows (a) the objects which children said were living, and (b) the number of children in each of the 4 groups who said that the object was living.

Note 'W' indicates "would be living if given right conditions"

_ indicates object was not used in test.

Table 2.1

Discussion-test	1	2	3	4
No. of children in group	3	5	6	4
Pet animals	2	5	5	4
Live insect	-	3	5	4
Pot plant	2	2	5	4
Cut Flower	2	0	3	2
Tree	3	3	6	-
Grass/Moss	2	4	6	4
Green leaves	1	2	4	1
Twig	0	0	0	2
Mould	-	2	3	4
Berries	0	0	0	3
Seeds	2W	4W	4W	4
Germinated seed	-	5	6	4
Cone	-	1	0	3
Rice	1W	0	0	2
Nut	2W	-	0	2
Egg	2	0	5W	3W
Carrot	-	-	3	1,1W
Apple	0	0	-	3
Potato	0	0	2	4
Crystals	3	1	3	2
Clock	1	0	-	-
Battery	0	1	5	0
Radio	1	-	-	-
Lit Candle	1	0	4	0
Flame	2	5	5	0
Sun	-	3	4	2
Moon	-	2	0	0
Wind	-	2	3	0
Water	0	0	1	0
Wood	1	0	0	0

2) The following table shows (a) the items which children said were either Not Living (N.L.) or Once Living (O.L.), and (b) the number of children from each of the four groups which placed the item into either category.

Table 2.2: Objects Included as Not Living or Once Living

Discussion-test	1		2		3		4	
No. of children in group	3		5		6		4	
ITEM	N.L.	O.L.	N.L.	O.L.	N.L.	O.L.	N.L.	O.L.
Cut flower	-	-	3		0	1	1	
Green leaves	1		3		0		1	
Brown leaves	3		4		4		1	
Twig	0	2	4		0	4	1	1
Mould	-	-	1		1		0	
Dead Insect	2		0	3	0	2	4	0
Aphid in slide	1		2	0	0	4	0	4
Berries	1		3		1	3	0	
Cone	-		2		0	5	2	4
Rice	0		3		0	4	0	
Nut	0		0		0	3	-	-
Egg	0		3		0		0	
Apple	0	1	3	1	-	-	-	-
Potato	0	2	3		0	4	0	
Carrot	0	2	-	-	0	2	0	
Bread	2		5		1		-	-
Sugar	2		2		0	5	3	3
Stone	2		4		4	1	4	
Shell	1		2		3		1	3
Feather	0	1	3		0	2	0	4
Rabbit-tail	0	2	3	1	0	3	0	3
Leather	0		1	2	1	4	0	4
Cork	0	2	2		0	5	1	3
Paper	0	2	3		-	-	-	-
Crystals	0		2		1		2	
Bubbles	2		4		1		-	-
Clock	2		3		-	-	-	-
Battery	2		3		1		4	
Radio	2		-	-	-	-	-	-
Candle	3		1		3	2	1	3
Lit candle	2		5		0		0	
Flame	1		0		0		4	
Sun	-	-	0		0		1	
Moon	-	-	0		1		3	
Wind	-	-	0		1		3	
Water	2		-	-	1		1	
Wood	0	1	1		1		2	
Soil	2		3		3		2	2
Coal/Oil	0	1	2		1	1	-	-

3) The ages of the children who said that the following objects were living (as in Table 1) are shown below:-

Table 2.3 Ages of Children who Included Object as Living

Discussion-test	1	2	3	4
No. of children	3	5	6	4
Ages of children	5,8,10	6,7,7,8,9	5,8,8,8,10,10	7,7,9,9
OBJECT	Ages of children giving response			
Pet animals	8,10	6,7,7,8,9	5,8,8,10,10	7,7,9,9
Live insect	-	7,8,9	8,8,8,10,10	7,7,9,9
Pot plant	8,10	7,8,9	8,8,8,10,10	7,7,9,9
Cut flower	8,10	0	8,10,10	7,9
Tree	5,8,10	6,7,8	All	-
Grass/Moss	8,10	7,7,8,9	All	7,7,9,9
Green leaves	10	7,8	8,8,10,10	9
Twig	0	0	0	7,9
Mould	-	7,9	8,10,10	7,7,9,9
Berries	0	0	0	7,9,9
Seeds	5,10	6,7,8,9	8,8,10,10	7,7,9,9
Germinated seed	-	6,7,7,8,9	All	7,7,9,9
Cone	-	9	0	7,7,9
Rice	10	0	0	9,9
Nut	8,10	-	0	9,9
Egg	8,10	0	5,8,8,10,10	7,9,9
Carrot	-	-	8,10,10	9
Apple	0	0	-	7,7,9
Potato	0	0	8,10 7,7,9,9	
Crystals	5,8,10	7	8,8,10	7,9
Clock	5	0	-	-
Battery	0	6	5,8,8,8,10	0
Radio	5	-	-	-
Lit candle	5	0	5,8,8,10	0
Flame	5,8	6,7,7,8,9	5,8,8,10,10	0
Sun	-	6,8,9	5,8,8,10	7,7
Moon	-	8,9	0	0
Wind	-	7,8	5,8,10	0
Water	0	0	10	0
Wood	8	0	0	0

Section 2: Children Talking

The following section is composed of excerpts from childrens' conversations which ensued from the four Discussion-tests. All of these excerpts were taken from the transcripts.

Childrens' comments, which are of importance and interest, are shown for each object or set of objects which was discussed. Comments from each of the four Discussion groups are written separately under headings, D.T(1), D.T.(2) etc.

The questions which are placed in parentheses are questions which were asked by the interviewer. Where necessary, extra words have been included in parentheses to clarify an expression. The age of the child who made a particular comment is shown in parentheses at the end of the comment. In D.T.(3) the two children aged 10 are written as (101) and (102).

The objects, which were discussed, appear in the following order in this section. (They were not discussed in this order during the tests.)

Living/Dormant
Living Things
Seeds
Egg
Apple/Carrot/Potato
Parts of Plants

Non-Living:
Battery
Clock
Crystals
Flame
Sun
Wind
Particles
Stones
Objects of Plant Orign
Objects of Animal Orign

Living Things

The children were questioned about the objects which they had decided were living things, i.e. pet animals, insects, trees, plants, mould.

They were asked to give their reasons for thinking that these objects were living.

(i) Pet Animals (belonging to children)

D.T. (1)

"Pets are animals and they're alive animals. They've not been drowned or killed.They move. They act as good pets. You can feed them. They eat food. They bark ..... not all bark! " (8)

"They make squeaking noises" (10)

D.T. (2)

"'Cause they're moving" (7)

"'Cause it barks, and it would eat if you gave it something." (6)

"If it would die, it wouldn't eat." (9)

D.T. (3)

"It's moving." (8).

"It's breathing." (102)

"'Cause it isn't all old. It didn't look all old." (8)

"'Cause it didn't stink and go all shrivelled up." (101)

"They do smell all the time." (8)

(ii) Insects in container

D.T. (2)

"That fly will suffocate." (81/2)

"They're living cause they're moving." (6,81/2)

"They're moving their legs and everything." (9)

"'Cause they move about". (73/4)

"They're living 'cause you've got holes in the lid. They're breathing." (9)

"They would suffocate". (73/4)

(If it wasn't moving, would you say it was living?)

"No". (6,9)

"It was dead". (6)

"No. When they're dead they rot away". (73/4)

"Might be sleeping. You never know". (81/2)

D.T. (3)

"It's living. A dead thing doesn't move". (101)

(iii) Trees

D.T.(2)

"Yes, it's living till it's winter." (6)

"Then the leaves die." (73/4)

"The tree's still living but the leaves aren't". (81/2)

D.T. (3)

"It's not living if in summer they don't have any leaves. In winter the leaves come off anyway". (102)

"It's dead. 'Cause it hasn't got its leaves on". (5)

"Most things are dying". (101)

(iv) Plants

D.T. (3)

"'Cause it's green". (101)

"'Cause it's green and it's not all brown and shrivelled up." (101)

"And it's not all flopping down." (8)

"It's green". (81/2)

"Why do plants not have bones? " (8)

"They do. Their stalks and stems and trunks are ..." (101)

"They have ... em ... veins, sort of veins. Leaves have veins".(8)

"They have water in them. They don't have blood." (101, 102)

"Things that grow from the ground don't have blood." (8)

(v) Mould

D.T. (2)

"If it still grows, it will be living." (73/4)

D.T. (3)

"It is living, 'cause it keeps growing." (102)

"Yes. It smells." (8)

"Yes, cause it grows on stuff that's old." (101)

D.T. (4)

"It's living because it's a creature." (91/2)

"It's a creature." (7)

"It's a fungus and it's got all its things to live off." (9)

"It's growing." (7)

"Very gradually. Some people might think a plant was dead." (9)

Seeds (including Nut, Berries, Dried grass)

D.T. (1)

"If they were in the right conditions, they would be growing. They would be alive like a plant. There are things inside them which are ready to live". (10)

"I don't know ... If we could let them grow ..." (5)

"The nut would grow if you planted it. I suppose it is alive". (10)

"It was alive, and it might be alive if it's in the right conditions". (8)

"The seeds will be living but I don't really think the plant is". (10) (Dried Grass)

D.T. (2)

"They could grow. They could grow". (8)

"They would be living if you put them in ..." (6)

"Soil or something. They could grow". (9)

D.T. (3)

"They're living if you put them in earth. They ought to grow." (101)

"These (seeds) aren't living, 'cause they're not growing when they're like that". (102)

"They've got to be in the ground and they've got to have roots before they begin to grow. It's as though they'll come alive. They might be alive but just not growing". (101)

"'Cause they haven't got the soil and the water". (102)

"Haven't got the things. It will grow if it gets the proper ground". (8)

(Germinated seeds).

"They've all got roots" (8,81/2)

"They are living. So could all them (seeds) grow roots". (101)

D.T. (4)

"I think all seeds are living. Cress seeds after about a day form a coating, then they have a little shoot" (91/2)

"The berries are living. They've got a seed inside them." (71/2)

"I think you could revive some of these (berries) and let them take root, and they might turn into a plant." (9)

Egg

D.T. (1)

"Not the actual shell, but the contents inside are living." (10)

"I saw inside an egg. Part of it is living. I saw what was going to be a chicken in it." (8)

D.T. 2

"It's living, if the chick would come out." (9)

"If ... the chick would be living, but the egg wouldn't." (6)

"The egg needs to be warm before the chick comes out." (81/2)

D.T. (3)

"Not living. Unless it had a chicken inside it." (8)

"I think it is living. But it depends. Some of them do have a chicken inside, some don't." (101)

"The chick might come out." (5)

"The egg won't be living. It'll just be broken egg-shell." (101)

"The inside will be living." (102)

"The chicken will be living." (101)

D.T. 4

"A battery-egg isn't living ... 'cause it wouldn't have any living ... any embryo in it. The embryo is, I think it's more like the seed of a chick." (9)

"It might be living, unless the things inside were dead, 'cause chickens can be born dead." (91/2)

Apple/Potato/Onion/Carrot

D.T. (1)

"I think once the apple's been picked, it'll stop growing. It was living on a tree. The potato is not living at the moment". (10)

"Mmmm... It was once living.. em ... it was living". (8)

"The onion is not living now, but it was ... when it was in the ground". (8)

D.T. (2)

"They were living ... when they were growing, where they came from". (8)

"The apple's not living. I said the seeds are". (9)

"The things inside - the seeds - are living, but the apple's not". (7)

D.T. (3)

"It (carrot) was alive. It's the root of a plant". (81/2)

"It is alive. Cause if you cut the top off, it grows and it's got roots there". (at top). (101)

"No, that's not living (Potato), 'cause it hasn't got any roots". (102)

"Yes, it is living, because there should be eyes on it, and you put them into the ground". (101)

D.T. (4)

"The apple's living. It's living in its seeds". (9)

"Yes, it's living 'cause of the seeds". (71/2)

"Because there's seeds in it and they're living". (7)

(Carrot) "Well, it's difficult to say, 'cause sometimes people take carrot tops, and they take root in water, but not when it's withered (at top)". (9)

(Potato) "It's still living ... because ... these wee bits ..." (eyes)(9)

"There's seeds there". (eyes) (91/2)

"These bits (eyes) take root. It grows in the ground".(9)

"It sends out little sort of root things, and then you find lots more potatoes". (91/2)

(i) Cut flower(s)

D.T.(1)

"It's kind of half-living". (10)

"Has the jar got water in it?" (8)

(Yes)

"I think they (flowers) are living. That rose is suffering." (8)

D.T.(2)

"No, they've got no moisture." (9)

"They're dead just now." (7,9)

"They're not living, 'cause they're not in water." (6)

"Cause they're all dried up. That rose might be living, 'cause usually when roses are dead the petals fall off." (7)

D.T.(3)

"It (rose) is alive-dead. In between. Nearly dead". (8)

"I don't think it's dead". (101,102)

"I think it's dying, though, because the leaf is brown." (8)

"It's dying but it's not dead yet." (101)

"It was alive on the rose-bush." (8)

D.T.(4)

"Not living. Because plants, once they're picked are dead." (91/2)

"They're living, 'cause they aren't withered yet. When they're dry, they're dead."(9)

"They're nearly dead ... either dead or nearly dead. I can't see how they could ... if, say someone cut off their heads. Mmm." (91/2)

"If you stuck its end in water ... it would just root. It might take root. But if it doesn't have any leaves, then it won't . " (9)

"I think they're almost dead. Sort of." (91/2)

(ii) Leaves

D.T. (1)

"They could be just living. They're suffering. They will be suffering from ... em ..." (8)

D.T. (2)

"No, not living. They've been cut off the branch." (73/4, 9)

"They are living. They're green." (71/2)

"They're dead. Just 'cause, once they get picked and they're out of water. Well, no ... just picked off the tree, they have no things to live on." (73/4)

"Out of the soil." (9)

"They can't come alive again." (73/4)

D.T. (3)

"The brown leaves aren't living." (8,81/2,10,101/2)

"They're all brown and shrivelled up." (101)

" Cause they've fallen off the tree." (8)

"It's all shrivelled up like an old person. It's an old leaf. It's all dead." (102)

"If it's green it's living." (8)

D.T. (4)

"They are living. I got a leaf of a plant, and you stick the stalk in, and em, other leaves will start coming out." (9)

(iii) Twig

D.T. (2)

"It would be living if its on a tree, but I don't think now." (6)

"Once you pick it off a tree, it's not living." (9)

D.T. (3)

"It used to be living when it was on the tree." (8,81/2,10)

D.T. (4)

"It might be living." (91/2)

"No, I don't think so." (9)

"Well, there might ... in the very centre there. Yes, that white bit, tiny white bit. That might be living." (91/2)

"It's living for a while till it gets dry." (9)

"On the outside, then it goes to the inside." (91/2)

"I think it goes to inside and outside, 'cause if the outside's dead it can't get goodness." (9)

"No. Yes, I think it's dead now." (91/2)

(iv) Cone from a tree

D.T. (2)

"It's still living, 'cause it moves ..." (9)

"No. Once they fall off trees, they're not living." (7)

"It depends how long it's been off the tree." (9)

(Examines cone) "The inside's living but the outside's not." (7)

"The whole thing's living if it's got seeds." (8)

D.T. (3)

"That lives. Because it was alive on the tree, and inside it are ... "(101)

"There were seeds." (102)

"When this was on the tree, all the seeds would fall out. It's not living just now, no. It's the seeds that are growing, that are alive, not the actual cone."(101)

D.T. (4)

"That cone's got seeds." (71/2)

"The seeds are shed." (91/2)

"The seeds are out." (9)

"It's living because it moves, it moves. It adjusts to hot and cold weather..."(91/2)

"I don't think so. That could just be expanding and contracting, because water isn't living very much. I mean, em ... oxygen and H2O isn't living and it contracts or expands. I don't think it's living at all." (9)

"It's living! There's a seed in there!" (91/2)

"The seed's living, but it's not." (71/2)

"... but it's not. The seed is, I think." (9)

Non-living Objects

Battery

D.T. (1)

"It's not living, though some people say 'the battery's dead.'"(8)

"It's not living in the sense that it's growing. ' A living battery' means its got electricity stored inside it. It doesn't grow ... it supplies electricity, which is not really a living thing." (10)

D.T. (2)

"It's living because it's working, making that work." (6)

"It depends what it's living on. It depends what it does." (9)

D.T. (3)

"It's living because it's got electricity in it." (8)

"It isn't living, but it is what you can call 'alive' ... because electricity is very alive." (10)

"If it is working it is alive." (81/2)

"If it's a new battery it'll be alive." (81/2)

D.T. (4)

"Even if it's a live battery it isn't living." (9)

"It's got electricity in it ... but that's energy ... no, energy isn't living."(91/2)

"Electricity won't make it alive. It can't move, it can't ...It's dead even when it's got electricity in it." (9)

"It's dead even when it's alive!" (7)

Clock

D.T. (1)

"Is it working; do all the handles move round? If it'sworking, then it's living!"(5)

"No! The tape recorder's working and it's not living." (8)

D.T. (2)

"It's not living, but it works, though." (9)

D.T. (1)

"Well, most things that can sort of move or grow, we normally say they're living. I think they're living, as if it's not growing then it's dead." (8)

"If they're growing, they're alive." (5)

"Crystals don't actually know what to do, they just do it. They are living, but not like an animal more like a plant." (10)

D.T. (3)

"They're living, 'cause they wouldn't grow if they weren't ... 'Cause all growing things are living."

(Is a crystal growing, the same as a rabbit growing?)

"Well, I suppose it is, because if you count those (crystals) as plants .. then .."

(Do you see them like plants?)

"No, not exactly. The crystals are a bit like seeds, I suppose.

You put them in water ..." (10)

D.T (4)

"They're not living, as they're just chemicals which are shooting ... funny blobs. This (crystals) is a chemical thing; it's like mould and things. This crystal garden needs to grow a bit more." (9)

"Hey! If it grows, it is living! ... Or is that ... that's just the bits of crystal and water, bits of chemical." (91/2)

"Yes, I think it's the crystal solidifying." (9)

"Is rock living?" (91/2)

"Yes." (7)

"Is crystal kind of rock?" (91/2)

"No, I wouldn't say it is." (9)

D.T. (1)

(Light the candle)

"Now it's alive! Because the flame's ... look ... now the flame is alive, and when you blow the flame out ... it's dead." (5)

"No. The flame doesn't make the candle alive, but ... I wouldn't call the flame actually a living thing. It's just something that burns on something ... it's gas, kind of gas."(10) "You could say it's alive in one way ... because it sort of looks alive, and it's moving and it's growing." (8)

"I don't think it is acutally alive in the fact that it will grow. It just stays there. It depends on what it can burn." (10)

D.T. (2)

"Yes it's living, 'cause it needs air to live." (81/2)

"Yes it needs oxygen ... gives out carbohydrates." (9)

"Yes, it needs oxygen; if you put matches over it, they just go out, 'cause they've got no air." (73/4)

"Yes, 'cause it's up and not going out." (71/2)

"If it doesn't get oxygen it just goes down and away." (9)

D.T. (3)

"It's alive in a sense". (101/2,8)

"The actual flame is alive, sort of. We've already said that it's only the things that move and grow. But it shrinks, the wax shrinks." (101)

"It grows. The flame is alive." (8)

"It grows. It usually gets bigger." (101)

(Flame flickers)

"Because it's the air, the air ..." (102)

D.T. (4)

"I don't think it's living, even if it's em, something alive. No .. (7)

"... even if it's burning. No." (9)

Sun

D.T. (2)

"Not (living) at night". (6)

"The sun always lives". (81/2)

"It goes to America at night". (7)

"No, it doesn't. It goes to Australia, other side of the world". (81/2)

D.T. (3)

"We said the flame was living, so if the flame is living and the sun's just a great big ball of fire, which is just the same as flame ... it must be alive." (101)

"And it helps things to grow." (102)

D.T. (4)

"The sun is fire." (Living) (7)

"It's living because the sun can die, so it must be living." (71/2)

(When can it die?)

"It can blow up." (71/2)

"No, not blow up. It can die". (7)

"I don't think it's living. It's just another kind of star". (9)

"The sun's different, it's just a ball of gas. It's a burning ball of gas." (71/2)

"It's a burning ball of gas, burning slowly ... I think if the sun wasn't there, plants would die and so would animals die, and there would be nothing left, if it didn't go on." (9)

"And it would be an Ice Age again". (7)

Wind

D.T. (2)

"It's living, because it's blowing." (7)

D.T. (3)

"I think it would be alive, because the Holy Spirit's alive, and it's said (to be) as the wind." (101)

"It must be alive or it wouldn't be moving." (8)

"Yes, so it probably is alive". (101)

D.T. (4)

"No it's not. The wind's howling is caused by ... something moving." (9)

"Yes, so it probably is alive." (10)

Particles

D.T. (1)

"Bubbles are not living. There are things inside them that are living, minute little things. Germs, little minute things. Minute, tiny things."(8)

"Tiny particles, I think." (10)

"Well, the same as other things. There will be minute, little things in stones." (8) (Are these things living?)

"Yes. There are minute, tiny things in nearly everything, I suppose. The stone itself isn't living but all the minute creatures inside ... (are) ".(8)

D.T. (2)

"They (sugar crystals) are living. Cause the seeds, cause you get wee, tinsy seeds inside them, I think. Just ... no, inside .. no in crystals. Just wee, tinsy things about that size (very small) inside these" (broken piece of crystal of sugar). (73/4)

(Can you see these things)

"No. They're a wee .. something. Yes, wee things. I don't know." (73/4)

Stones

D.T. (1)

"I think it (stone) did grow, but you could hardly call it properly living. It'd have to grow, become..." (10)

"Compared to a mouse they are completely dead, but there are lots of minute creatures inside them." (8)

D.T. (3)

"I don't know if they're living or not, because they're not ... they don't grow." (8)

"If stones are made of crystals then they must be living if crystals are living. Yes. But if you put a stone in water it wouldn't grow." (10)

"If the gem-stone has crystals, it must be living as well, when the crystals are

separated. Maybe it was one crystal who started that (gem-stone). It grew and turned into a stone." (101)

Objects of Plant Orign

1. Sugar

D.T. (1)

"Sugar crystals - they were growing. They had to grow to become crystals. They grew, but I don't think they are growing any more. Not living at the moment." (10)

D.T. (3)

"It was alive. It came off sugar-cane. You can't exactly say it's dead though, because it's just the same sugar-cane when it was living. Just ' cause the sugar-cane's in the ground, doesn't make any difference if it's out of the ground." (101)

D.T. (4)

" No! It's been boiled and it's been crushed, and I don't know how anything living can go through all that! It was a cane of sugar." (91/2)

"Or else it was a sugar-beet". (9)

"It was living on sugar-cane." (7)

2. Bread

D.T. (1)

"Most edible things were living." (10)

"Bread is made of wheat or corn and that was definitely living. It must have grown." (8)

D.T. (3)

"I mean, in the normal sense, bread is not alive." (10)

3. Wood, Paper, Cork, Coal.

D.T. (1)

"The wood sort of feels alive. It feels alive." (8)

"It used to be alive but it's dead now." (10)

"Once upon a time this paper was alive and grew ... " (10)

"And it's quite hard to say .. hold this piece of paper up and say, Once this was a tree." (8)

D.T. (3)

"Cork is like sugar. It came from a thing that's alive. You can't say it's dead and you can't say it's alive." (10)

"It's not alive now." (5)

"Coal was living because ..." (101)

"Yes, because it grew in the mine. Oh, no, it's not. The coal wasn't alive."(102)

"No, it isn't. It's the trees crushed up together. So it was alive when the trees were alive, if you see what I mean". (101)

Objects of Animal Origin

Table 2.4

Object	Discussion Group	Comments (Age)
Shells	1	They grow. They're not really living. (10)
	2	Depends if there's animals in them or not. (9)
	3	There were animals in them which were alive . (8)
	4	The things inside them were living .(7)
		They weren't living, but they weren't dead. Sort of never living. (9)
Leather	1	It was the hide of an animal. (10)
	2	It was living when it was on cows. (7)
	3	It was alive when it was on a cow. It's cow's skin. (8)
	4	It used to be living tissue but now ... (91/2)
		It's dead stuff. (9)
Rabbit's tail	1	It was living when it was on the animal. (8,10)
	2	It was once living, 'cause it would be growing. (7)
	3	When it was on the rabbit, it was alive. (8,10)
	4	It's got bones in it which used to have living fibre. (91/2)
Feather	2	If it was on the bird it was living, as it would have to grow. Not now. (7)
	3	Yes, it was living, because it was joined on to the bird.(10)
		It falls off ... it wouldn't be. (8)
	4	It used to have blood going up there. It's dead now. (9)
		You find blood on the end of it. (91/2)
Dead Insects	1	They're not living at the moment. (10)
	2	That's dead. It'll be squashed. Also it'd have no air. (7)
	3	It's been preserved. (10)
Oil	1	Everyone calls oil dead, but if you go back, everything has to be made out of living ... living substance. (10)

Chapter 3

Interpretation of Pilot Study Results

1. Childrens' Beliefs about Objects

Animals

All of the children in the four groups were certain that their pet animals were living and there was no question about this. Several children stated that if the animals were not living, then they must be dead. The reasons which were given for animals being alive were 'They move', 'they feed', 'they make noise' and'they're not dead.'

The children were also certain that the insects were living, because of their movement and because there were holes in the container-lid to enable the insects to breathe. Without this observation of the holes, the children would probably not have spontaneously given breathing as an attribute of life. The preserved insects were said to be dead, but to have been living at one time. Two categories have emerged already: living, and living at one time but now dead.

Plants

Once more there were no doubts expressed about whether the pot-plant was living or not. They all said that plants were definitely living. The reasons for this included simple observations e.g. 'They're green', 'they're not flopping down.' Similarly, all of the children were sure that a tree is living. However, the youngest children said that trees were not living in winter as they have no leaves. The presence of green leaves seems to be to the children an indicator of life.

Cut parts of Plants

Leaves and flowers which had been cut from plants provoked a lot of discussion. Some children said that these could not be living since they were cut off the plant, while others, mostly in the age range 8 to 10 years, said that these parts were living if they were still green or unwithered, or if they were in water. The idea of a plant being able to feel was introduced by one boy, aged 8, who described the cut pieces as "suffering." One boy of 9 described how a cut stalk could still grow if it was rooted and placed in soil. He was aware of reproduction in plants.

Mould

Generally the children were not sure whether mould was living or not and two children said that it was not living. They all seemed to be unfamiliar with mould and had never

considered it as a living thing like a plant or animal. However, in Group 4 every child said that it was living. All of the children found it difficult to give reasons for mould being living but a few, aged 7 upwards, said that, if it grows then it must be living. It appears that a child has to know of some attributes of life before being sure that an object is living.

Seeds

Seeds by themselves were mostly said to be non-living, whereas the germinated seed with its tiny root and shoot was classed as definitely living. In Group 4 seeds were immediately classed as being living. After some discussion in the other three groups the general conclusion was that seeds "would grow" and therefore they "would live" if given the right conditions; i.e. if planted in soil. This view was held by the youngest children, aged 5 and 6. Thus the concept of dormant life or potential for life was expressed by some children at each age level.

Fruits

With regard to berries, apple and pine-cone, these things were said to be not living but the seeds inside them were classed as living. One boy, aged 9, expressed this as "It's living in its seeds." The fact that the objects contained seeds did not come forth immediately, but it resulted from discussion about what each object consisted of.

In Groups 1 to 3 no child said that berries were living: the same occurred in Groups 1 and 2 with Apple. Similar results appear with Rice, Nut and Pine-cone. Their reason was that these things have been removed from the plant. By contrast, in Group 4, most of the children included these objects as living because of the seeds inside them. Thus there is variety in the views held by different children of the same age. Here, it seems to depend on what they already understand and know about an object.

Egg

Some children did not think that an egg was living or that it would live. Others said that if it had a chicken inside it, or if the chick came out, then it would be living. Once more the concept of dormant life was expressed by some children. One boy, aged 9, mentioned the embryo and described it as the "seed of a chick." There was considerable discussion in three of the groups about whether the egg was a battery egg or a free-range specimen. The children decided that if it was a battery egg, then it would not have a chick and would not be living. They were capable of continuing a logical argument and arriving at a conclusion.

Vegetables

The potato, carrot and onion were said by most children to be not livng. Several children said that the vegetables were living when they were in the ground but not at present. Being in the ground seemed to be associated with growing.

The children who classed them as living talked about planting them, if they had shoots or roots, and of getting more vegetables produced. They were speaking from their own practical experience and, as a result, they decided that the vegetables were living. This knowledge of plant reproduction also emerged when cut stalks were discussed. It is clear that some children have more sophisticated knowledge than others and that this affects concept development.

Non-Living Objects

Crystals

At least one child in every group thought that the crystals in the Crystal Garden were living. The reason which was given was that the crystals were growing and therefore they must be living since "all growing things are living." A few children also said that the crystals were similar to plants or to seeds growing. Here, their decision was based on observation.

However, some children were certain that the crystals were not living. They were not deceived, as it were, by the appearance of the Garden. One boy, aged 9, described them as "just chemicals." He was able to recognise that they were made of non-living material. The dry crystals did not cause the children to change their decisions, perhaps since they were told that the Crystal Garden was made by placing crystals into a solution.

Stones

Stones were classed very definitely as non-living. Several children in more than one group discussed the idea that a stone once grew, perhaps from crystals, but they still said that it was not living. Coal was placed in the same category and the older children described how it was formed. A boy of 10 described oil as "once living if you go back in time."

Battery

Most of the children immediately said, " A battery is living." Then they thought about what they had said and qualified it with a statement like, "You call it living, but it's not alive." After questioning them about these ideas, most children stated that a battery did not have life like that of an animal or plant. It merely had "power" and "could make things go." They knew that a battery could be called 'living' or 'dead' and that this related simply to the power or

electricity in it. This view was held by children of all ages, including 5 year olds. In Group 3, where five children decided that a battery should be classed as living, language seemed to have a strong influence on their decision, whereas in other groups language was of lesser importance.

Clock/Radio

Only one child of 5 was certain that a clock was living. His reasons for believing this were, "It moves" and "It works." The same child also thought that a radio was living. The other children said that a clock was definitely not living and children, aged 8 to 10 years, found it laughable to think of a clock as being living. This shows a development of the life concept with age. The simple idea is that if an object moves and works, then it is living, but this idea is not retained as the child gets older.

Flame

In Groups 1 to 3 nearly every child said that the flame on the candle was living. Results are almost the same as those for Pet animals and Pot plant. The main reason for the flame being living was its movement; other reasons included "growing bigger" and need for air. Even although a flame does not move or grow very much and the need for air is not connected with breathing, these attributes cause children to say the flame is living. A few children, including the two 5 year olds, stated that the candle became alive when it was lit. Children in Group 4, by contrast, were certain that the flame was not living.

Sun and Moon

Several children including the youngest said that the sun was living and gave various reasons for believing this. In Group 2 children spoke of the sun almost like a person "going to Australia at night". In Groups 3 and 4 the sun was compared with the flame or with fire. Two 7 year old children said that the sun must be living, because someday it could "blow up and die," i.e. if it is able to die then it must be living. One boy of 9 mentioned that if the sun did not exist, there would be no life on the earth. He was the only child who stated that the sun was not living.

The moon did not evoke such a clear response as the sun which seemed to be of more importance to the children. Perhaps this is because the moon is visible far less often than the sun. Only two children in Group 2 said that the moon was living, and four children altogether said that it was not living. There were no references made to the Man in the Moon.

Wind/Water

Some children said that the wind was living, including one 5 year old. The main reason was that it moves and blows things around. One girl, aged 10, compared it to the Holy Spirit which according to her was alive and therefore the wind must be alive. She had called other thoughts to mind in order to make her decision. She also said that water is living because of its movement; in this case she was basing her decision on an observable attribute.

Objects which were living at one time

Several different objects were placed into this category by the children. Some objects were said to be living when they were part of an animal or plant, e.g. Feather, Leather, Rabbit's tail. Most children did not think of bread and sugar as being living, but they described how these foods were made from living plants like wheat and sugar-cane. Two children said that paper was living at one time, because it was a product of trees. Cork was described in a similar way.

This agrees with the general belief held by the children regarding parts cut from plants e.g. twig, leaves, pine-cone, that these were not living if they had been removed from the plant. An exception was the piece of wood, which one child, aged 8, said was living. In every group soil was described as having living things present in it, such as small animals, insects and plants, but the soil itself was not living.

In summarising the results, the objects can be placed into certain categories and some objects can be grouped together according to their common attributes. These are based largely on the responses which the children have given and are shown in Table 3.1.

2. Attributes of Life

When children were unsure whether an object was living or not living they were often basing their decision on the attributes of life which they believed the object to have. Often a child would say,' If it does this, then it must be living.' This is like a mini-theory which is produced by the child in an attempt to decide whether an object is living or not. It could be called an alternative framework, especially since the child usually came to the wrong conclusion. e.g. "If crystals grow, they must be living", or "Water must be living because it moves."

In other cases an attribute would cause the child to come to the correct conclusion e.g. mould and vegetables can grow therefore they must be living. Overall, movement and growth

were the two most common attributes which children used for both living and non-living objects. In addition, the idea of "needing air" was used for both living insects and flame, and not for any other living thing.

Table 3.1

OBJECT	RESPONSE OF CHILDREN	CATEGORY
Pet Animals, Insects	All certain - living.	Living. Animal life.
Pot-Plant, Grass/Moss	All certain-living. Green.	Living. Plant life.
Tree	All certain - living. Some say it dies in winter.	Living. Plant life.
Mould	Most not sure. If it grows, it's living.	Living. Static. Growth
Potato, Carrot, Onion.	Most not sure. Living in ground, but not now. Some say it can grow.	Living.Dormant life.
Cut parts of plants	Not living if off the plant. A few think - still living.	Living for a time. Some dormant life.
Seeds Berries Apple Pine-Cone Egg	Most agree - potential for life if it grows. Seeds inside Cone/Apple are living. Egg - a lot of controversy.	Living. Dormant life. Potential for growth.
Crystals	Some sure - non living. Some sure - living. Growth.	Non-living. Growth
Battery	Language - 'living' or 'dead' battery, but not like animal/ plant.	Non-living. Has 'life' Non-living. Has 'life' or 'power'.
Stones	All certain - not living.	Non-living. Static. Cold
Clock/Radio	Only one child (5) - living. Moves/works.	Non-living. Movement, noise.
Flame	Some sure - living. Moves, grows. Some sure - non-living.	Non-living. Movement, growth.
Sun, Moon, Wind	Some sure - living. Moves. Gives life. Wind - moves i.e. living.	Non-living. Intangible (Sun) Gives life.
Bread, Sugar, Wood, Paper, Cork Coal.	Living at one time or came from a plant.	Non-living. Of plant origin.
Fur, Leather, Shells, Feather. Dead insects, Oil.	Living at one time or came from an animal.	Non-living. Of animal origin.

3(a) Age related differences

The results show differences in childrens' responses which may be related to age. Some examples include children, aged 5 and 6, believing that a flame is living while a 10 year old child disagrees, and a child, aged 5, saying that a clock is living while older children disagree. There may be a development of the concept of life with age, but, with such small numbers of children in the groups, it is difficult to show definite patterns in the childrens' beliefs. The same applies to any differences in responses between the sexes.

(b) Group Differences

The results for Group 4 show very strikingly that these four children have a more developed concept of life than the other children in the Study. Results for Group 4 show that most of the children have placed objects into the correct categories. Two exceptions are 'Crystals' and 'Sun' where two children in each case placed the object into the living category and gave their reasons for doing so.

The reason for the more developed concept may be a sophisticated family background and greater parental involvement in their education which has given a more scientific awareness of things. The four children came from two different families. One of the boys, aged 9, who had a well-developed concept of life, may have had some influence on the others, but he in no way dominated the group.

4. The Particles Idea

Two boys, aged 73/4, and 8, in different groups spontaneously expressed a belief that there were tiny particles, which are living, inside every substance. The child of 8 referred to these "minute, little things" as being inside bubbles and stones. He was convinced that these "minute creatures" were living. The other child referred to "wee, tinsy things" or "seeds", which were living, inside crystals of sugar. He seemed to be unsure what these things were.

It cannot be stated from this finding alone whether this belief is a common one or merely an isolated one which is not held by any other children. It may be a misconception which has resulted from reading or hearing about atoms or particles. Further interviewing of children would have to be carried out to gain more information.

5. Limitations of the Pilot Study

Since there were only four groups, containing between three and six children, involved in the Pilot Study, it has limitations where deriving information is concerned. Definite

patterns in beliefs are not evident with a small sample of children.

The following factors could have affected results:-

1) Children "follow the group", agree with others and are afraid to be different.

2) Temperament differences i.e. shyness of some children and over-talkativeness of one or two in the group, regardless of age.

3) Unwillingness of child to tell a stranger or adult their ideas.

4) Children not meaning what they are saying.

5) Middle-class background of all the children: most of their parents have professional occupations.

Conclusion

From the Pilot Study the following items emerge which should be further investigated:-

1) Childrens' beliefs about whether an object is living, not living, or was living at one time.

2) The attributes of life which children give to various objects, both living and non-living.

3) The development of the concept of life with increasing age, and possible sex-related differences in beliefs.

4) Childrens' beliefs about particles. Another possibility would be to find out whether children thought that microscopic animals and plants were living or not.

The next stage in the project was to carry out a similar study with a large sample of about 500 children from different backgrounds and in the age range 5 to 10 years.

Chapter 4

School Study - Methods

Introduction

The next part of the project, which was to be carried out in schools, was based on the results from the Pilot Study and not on researcher's ideas and preconceptions. The School Study was designed in order to gain more information about issues which had arisen during the childrens' discussions in the Pilot Study, and the design was based on ideas which the children had brought to the fore.

Aims

The aims of the School Study were:-

(a) to question a large sample of children in a similar way to that which was done in the Pilot Study.

(b) to find out childrens' beliefs and ideas about living things

(c) to study the development of the life concept with age, from age 7 up to 11.

(d) to examine differences in responses of boys from those of girls.

(e) to find out childrens' ideas about microscopic things.

(f) to use a Computer Game to find out if, in this way, more information could be obtained from pupils.

Procedures

(a) Schools

The School Study was carried out during January and February 1984 in 6 Primary schools in Lanarkshire. Five of the schools were in towns and one was a rural school. Permission had been given by the Divisional Education Officer and the Primary Science Adviser for Lanarkshire to enter the schools.

In December 1983, arrangements were made to visit each school and the proposed project was discussed with the Head Teacher. A further visit to each school to discuss the project with the teachers whose classes would be involved was arranged for January 1984: due to adverse weather, however, these visits had to be cancelled. In place of this, a pack of information about the project and methods of testing, containing a copy for each teacher, was

sent to each of the schools.

(b) Methods of Testing

Pupils in the classes from P.3 up to P.7 were included in the sample i.e. pupils from age 7 up to age 11. For the purposes of this project, it was decided that pupils below age 7 would not be included. About 30 pupils at each stage in each school were involved, except at the rural school which had a total of 15 pupils in the age range from 7 to 11.

In order to question the large number of pupils, a simple work-sheet was designed, which was based on the results from the Pilot Study. The work-sheet was only administered to classes from P.4 up to P.7 (age 8-11). After consultation with some Primary teachers, it was found to be too difficult for P.3 pupils to complete. Instead of the work-sheet, P.3 pupils wre given interviews using the questions on the work-sheet, and their answers were noted. One day was spent at each of the 6 schools. A convenient time was arranged during the day at each school, when some P.7 pupils could play the Computer Game.

(c) Format of the Work-sheet

1. The first page of the work-sheet named "Living or Not Living" contained a 16 box grid, (See page 51) which was to act as a Structural Communication Grid (102). This is a structured method of finding out a person's concept. It consists of a grid of boxes with one object in each box. From examining which objects a child selects and which ones he/she omits, a picture of the child's concept is built up.

The advantages are that,

1) The child selects for him/her self,

2) The grid is visual and easy for a child to read, understand and select from,

3) Objects included as well as omitted provide information.

In designing the 16 box grid, objects were chosen from the ones used in the Pilot Study, which represented certain categories or which had yielded a lot of discussion and argument. In this way, a clear picture of each child's concept of life should be obtained.

The 16 objects included 6 living things, 6 non-living things, and 4 non-living things which came from a living thing. The objects were (apart from Crystals and Mould) things with which any child would be familiar..

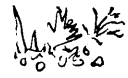
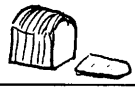
LIVING OR NOT LIVING?

Name _____ Class _____ Age _____

Boy _____

Girl _____

TICK ONE

1. Potato 	2. Clock 	3. Tree 	4. Mould 
5. Sun 	6. Fruits 	7. Crystals 	8. Cow 
9. Plants 	10. Flame 	11. Meat 	12. Battery 
13. Bread 	14. Stones 	15. Leather 	16. Sugar 

READ THIS CAREFULLY:-

Here are some boxes with pictures. The questions all refer to these pictures. The answers to Questions 1, 2, and 3 are just box numbers. For example, if you were asked, which boxes contain something you can eat, the answer would be 1, 11, 13, 16.

Now try to answer the questions.

---

1. Which boxes contain something which is still living?

2. Which boxes contain something which is not living now, but came from a living thing?

3. These things are not living now, but they came from living things which are shown in the boxes. Find these living things and write your answers like this -

Not living now	The living thing it came from

Turn over

The objects chosen were as follows:-

A. Living Things.

Object(s) in Pilot Study	No in grid	Object	Category
Potato/ Carrot	1	Potato	Dormant life
Seeds, Berries Apple, Cone, Egg.	6	Fruits	
Pot Plant	9	Plants	Plant life
Tree	3	Tree	
Pet Animals	8	Cow :	Animal life; movement
Mould	4	Mould :	Static life; neither plant nor animal.

B. Non-living things

Pilot Study	No.	Object	Attributes of life
Clock	2	Clock :	Movement, noise
Sun	5	Sun	Movement, heat, light.
Flame	10	Flame	
Crystals	7	Crystals -	Growth
Battery	12	Battery -	Gives 'life'/power
Stones	14	Stones :	Static, no heat.

C. Non-living from Living

Pilot Study	No.	Objects	No.
Objects of Animal Origin	11	Meat FROM Cow	8
	15	Leather " Cow	8
Objects of Plant Origin	13	Bread " Plants	9
	16	Sugar " Plants	9

The box-grid was designed in such a way that objects which were omitted by a pupil, as well as those which were included, would provide information about the pupil's concept of living things.

For Question 1- "Which boxes contain something which is still living,"- this would be as follows:-

Objects included	Objects omitted	Concept
1,3,4,6,8,9	All others	Complete
3,8,9	1,4,6 and others	Incomplete. No idea of dormant or static life.
3,8,9,7	1,4,6 and others	Incomplete (as above) "Growth" dominant
3,8,9,5,10	1,4,6 and others	Incomplete (as above) Heat & movement dominant
1,3,4,6,8,9,7	All others	Incorrect 'Growth' dominant
1,3,6,8,9	4 and others	Incomplete - includes only animal and plant life
3,4,8,9	1,6 and others	Incomplete. No idea of dormant life
2 and various others	Various others	Incorrect. 'Movement' dominant
12 and various others	Various others	Incorrect. Misconception of words 'life' or 'alive'.

Similarly, for Question 2 - "Which boxes contain something which is not living now, but came from a living thing?"- it is as follows:-

Objects included	Objects omitted	Concept
11,13,15,16	All others	Complete
11,13,15,16,1,6 or 1,6	All others) All others)	No concept of dormant life
11,13,15,16,1, 4,6 or 11,13,15, 16,4.	All others) All others)	No concept of dormant or static life.

Also, for Question 3, where pupils were asked to match their answers from Question 2 with the living thing each one came from, it would be as follows:-

NON- LIVING	FROM	LIVING
11	"	8
13	"	9
15	"	8
16	"	9

Corect Concept

OBJECT	FROM	LIVING THING
1	"	9
6	"	3 or 9

Incorrect Concept
No concept of dormant life

2. On the second page of the work-sheet (See Page 56) there were two further questions which did not refer to the objects in the box grid. Question 4 was about microscopic living things. It was included in order to obtain more information about a possible alternative framework which had arisen during the Pilot Study, i.e. a belief that tiny living particles exist in every substance.

Question 5 was included in order to find out the attributes which children use to describe a living thing. It was the last question on the work-sheet so that pupils would have time to think of questions, pertaining to an imaginary living thing, and write them down. This method was thought to be the best way to obtain childrens' natural responses.

(d)Class-room Procedure

In the course of the day spent at each school, each of the classes from P.4 up to P.7 was tested separately. The time spent in each class varied between 30 and 45 minutes, depending on how easily pupils were able to fill in the work-sheet. The teacher remained in the class-room.

Before pupils received their work-sheets they were given a short explanation about the purpose of the test, i.e. it was to find out their own ideas about living things. They were shown a copy of the work-sheet, and Questions 1,2 and 3 were explained to them. The names of the objects in the box-grid were read aloud. They were told not to copy someone else's answers or discuss answers with anyone, and they were only to ask for help if they could not understand a part of the work-sheet.

To make sure that all the pupils knew what the objects looked like, they were shown specimens of some of the objects. The following specimens were carried round the class so that each pupil could see them at close quarters:

A Crystal garden in a jar

a sample of dry Copper sulphate crystals

some mould on a piece of fruit.

It was explained to them that the Crystal Garden contained crystals similar to the dry ones, but the words "growing" and "garden" were not used. Similarly, they were told that mould was found on various things, and the word "growing" was not used. Pupils in P.4 and P.5 required more detailed explanations than older pupils.

Each pupil was issued with a work-sheet and asked to answer Questions 1,2 and 3 and then await further instructions. The pupils were observed during this time to make sure that they understood the questions and that they were writing answers as clearly as possible.

When every pupil had completed the 3 questions to the best of their ability they were asked to turn to the second page of the work-sheet. Before explaining Question 4, the class was asked if they knew what a microscope was. Usually some pupils were unsure, especially in P.4 and P.5 classes, therefore an explanation was given about the uses of a microscope, and a picture of one was shown.

Pupils were then shown three photographs: one showed some microscopic plants, another some microscopic animals and a third one showed a crystal viewed under the microscope. Question 4 asked the pupils: which are living things, out of these three categories of things which are only visible using a microscope? They were asked to tick one or more than one of the three - tiny animals, tiny plants and tiny particles.

Before beginning Question 5, pupils were asked to imagine that there was something, which is living, in a box in the class-room. They were asked to write down the questions they would want to ask, in order to find out if the object is alive or not. An example, "What colour is it?' was given to help them. They were told to write down as many questions as they could think of. When every pupil had finished writing, the work-sheets were collected together, and the pupils were thanked for their co-operation.

At the rural school there was some time and opportunity to question the 5 P.7 pupils orally about their written responses on the work-sheet. This provided more information about older pupils' reasons for including an object as a living thing.

4. Some living things are so tiny you cannot see them with your own eyes. You need a microscope.

Which do you think are living things?

tiny animals	
tiny plants	
tiny bits or particles	

Tick one, or more than one, of the boxes.

Now wait until everyone has finished before you start Question 5.

5. I have something in my hand. What questions would you ask me if you wanted to find out if it is alive? Write your questions below.

_____

_____

_____

_____

Make sure you have answered all the questions.

Don't forget to write your name, age and class at the beginning of the sheet!

(e) P.3 Pupils (Age 7): Individual Interviews

Since time was a limiting factor, pupils were interviewed in pairs, so that as many as possible could be included. The pairs were selected at random by the class-teacher and included children of different abilities. If time permitted, as many as 12 pupils were interviewed, but at some schools there was time to interview only 4 or 6 pupils.

Interviews lasted for about 15 minutes. They were held in an informal manner and the pupils were encouraged to talk and express their ideas. They took place in a suitable area outside the class-room. The two pupils were seated at a table on which the following objects were placed, which they could look at and handle:-

Crystal Garden

Dry Copper sulphate crystals

Mould

Battery

Apple

A lit candle (Flame)

Stones

Each pupil was given a copy of the 16 box-grid to look at. The name and number of each object was read out to them and, where necessary, a specimen of the object was pointed out. The two pupils were then asked all of the questions from the work-sheet. Pupils were told to give their own answers and not to copy each other. Naturally, it was realised that one of the two pupils might give the other one ideas.

For Question 1, they were simply asked to say which objects they thought were living things. If a pupil erroneously said that a non-living object was living, they were asked to give their reasons for thinking this. Their answers and reasons were noted on a copy of the work-sheet. For Question 2, they were asked to pick out the objects which are not living now but came from a living thing. For each object which they picked out, they were then asked from which living thing it came. (Question 3)

Before answering Question 4, the two pupils were shown the same photographs as the ones used in the class-room tests of things seen under the microscope. They were also shown the picture of a microscope. Its use as an instrument for observing things which are too small to be seen by the human eye was explained. They were asked if they thought that microscopic

nimals and microscopic plants are living things. Then they were asked if the tiny particles making up crystals are living. Their answers were noted.

At Question 5 the pupils were asked to imagine a cow in a field next to the school. At the first school, this method was found to be the most effective way to obtain answers to the question, "How do you know something is living?" If they were asked the question merely in an abstract way, children aged 7 found it difficult to give answers, but if they were imagining a familiar animal they were able to respond. They were asked to imagine they were watching the cow, and to say how they would know it was a living thing. Their answers were noted on the work-sheet. In some cases, responses to Question 5 were also tape-recorded, so that no information was lost.

(f) Computer Game

Aims

An attempt was made to gain more information about pupils' ideas of living things by studying their responses which they have "typed in" to a computer.

It was thought that:-

(a) they may give information to the computer which they would not give on a work-sheet or in an interview.

(b) they may be more willing to confide in the computer than in a person,

(c) they may be able to think more clearly while working alone at a computer, and may therefore give responses which more genuinely reflect their ideas.

Preparation of the Game

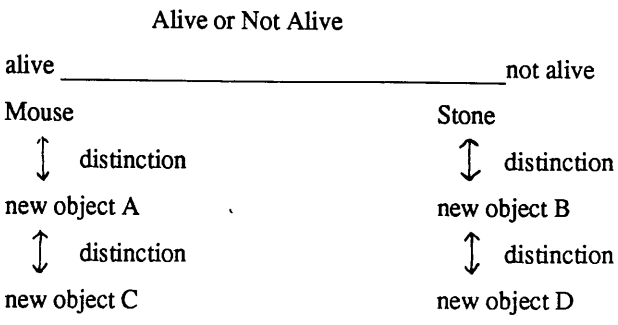
The Computer Game named "Alive or Not Alive" was prepared during November 1983 by making alterations to the existing program of "The Element Game". The altered program was very similar to the original one, since the game "Alive or Not Alive" was to operate in the same way as "The Element Game". Instead of pupils teaching the computer about certain chemical elements, they would teach it about the different objects from the box-grid. The program was stored on disk and run on an Apple II Computer from the University. Instructions and typed-in responses appeared on a screen.

A print-out of the computer program is enclosed at the end of the thesis.

The Game "Alive or Not Alive"

This is a game which allows the pupil to teach the computer. In this way the pupil will expose his/her own ideas to the "dumb" computer, whereas in the presence of an adult he/she might be less willing to reveal his/her ideas. In this game the computer would no longer ask the questions from the Element Game. Instead it would ask whether different objects are living or not.

The structure of the program is as follows:-



When an object is typed in, the computer asks, "Is it living?"' Pupils answer by typing in "Yes" or "No". The Computer already knows two objects, in the same way as it knew two elements, one living object (Mouse) and one non-living (Stone).

If a pupil answers "Yes" to the question, "Is it living" the next question the computer asks is, "Is it a mouse?" If the answer given is "Yes," the computer answers, "I got it right. Now teach me another". If the answer is "No", the computer asks for a question which will distinguish between Mouse and the unknown living thing. The pupil then has to type in a suitable question, and the name of the living thing, and thus the computer "learns" another object.

Similarly, if the answer to, "Is it living," is "No", the computer asks, "Is it a stone?" To teach the new object, the pupil types in a question which will distinguish Stone from the new object.

In this Computer Game an infinite number of objects could be taught to the computer, but for the purposes of this project, six objects was thought to be a sufficient number. This would mean that more pupils would have a chance to play the game and their responses would relate to a certain set of objects. The objects (3 living and 3 non-living) were:-

Apple	Battery
Rabbit	Crystals
Spider	Flame

The following short work-sheet was prepared for pupils to use while playing the game. There was a space where the pupil had to write each object under one of two headings, "Living" or "Not Living". Thus the pupil would have clearly decided into which category he or she had placed each object, and this could be used as a check when the responses given to the computer were being studied.

ALIVE OR NOT ALIVE: a Computer game

Name _____ Class _____ Age _____

Here is a list of things:-

Apple Spider

Flame Crystals

Rabbit Battery

Divide them into two groups, those which you think are living and those which you think are not living.

Write your answers in the space below:

Things which are LIVING	Things which are NOT LIVING

Now read these instructions on how to play the Computer game - "Alive or Not Alive".
In this game you are going to teach the computer all the things on the list. It will ask you the question about each thing, Is it living?
First of all, teach it each of the things which are LIVING.
Answer YES to "Is it living?" It already knows one thing which is living - MOUSE. Do as it tells you , and teach it the other living things on your list, one by one.
Then teach it each of the things which are NOT LIVING. Answer NO to "Is it living?" It already knows one thing which is not living - STONE. Do as it tells you again, and teach it, one by one, the other things which are not living.
I hope you have enjoyed playing the game.

Procedures

a) Preliminary

Before the Computer Game was taken to a school, a few children of different ages were invited to play the game at the University. This was necessary, in order to make sure that the instructions, both on the computer-screen and work-sheet, would be easily understood, and to find out how the children responded to questions asked by the computer.

Three children, aged 7,9 and 10, from the University Creche played the game one after another. The game proved to be rather difficult for the 7 year old child, especially where the formulation of questions was concerned. The 9 year old child also had some difficulties with understanding. However, the 10 year old child required very little assistance and could understand the instructions and was able to formulate questions.

Therefore it was decided that the Computer Game would be played only by P.7 pupils (age 11), since time in schools would be limited. The work-sheet "Living or Not Living" was to be the main method for gaining information from pupils, with the Computer game providing additional information.

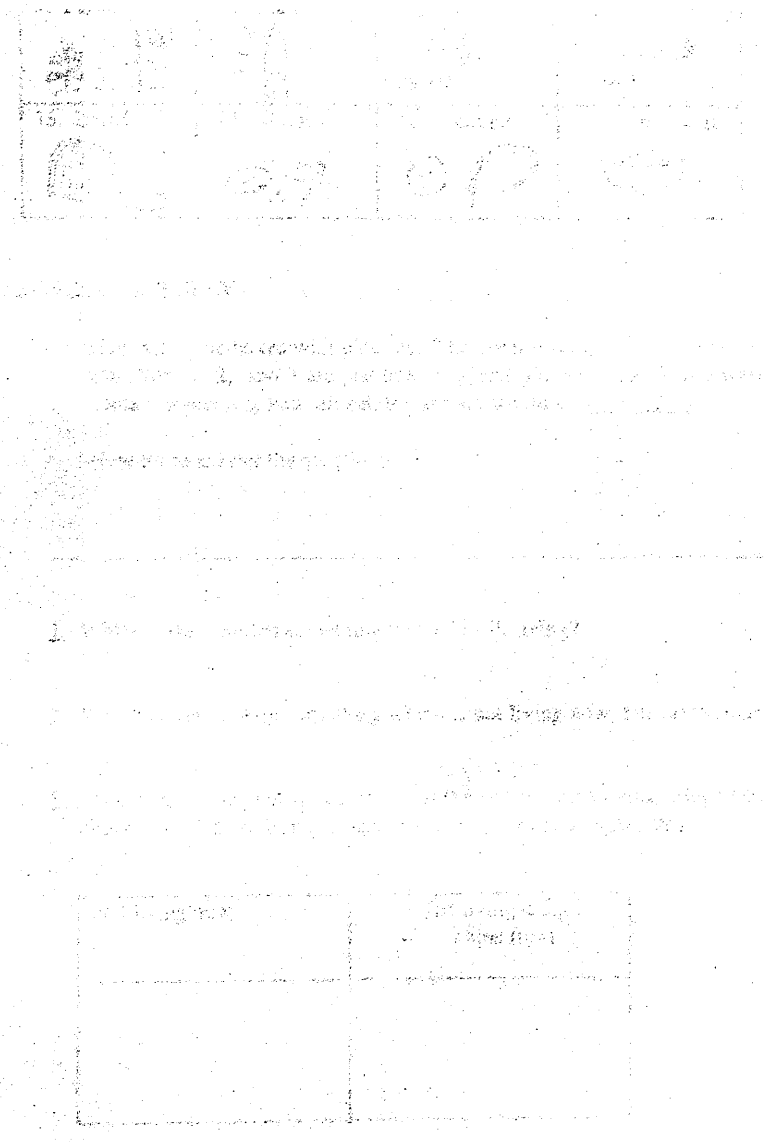
b) Schools

The Apple II Computer from the University was taken to each of the six schools, on the day on which the work-sheet were administered. The program on disk could not be run on other makes of computer. The Apple II was set up in a suitable area away from the class-room, and a convenient time was arranged in the day to allow several P.7 pupils to come and play the game. This was possible at 5 out of the 7 schools visited.

The number of pupils in each school who took part varied between 4 and 20, depending on time available. In some cases pupils played the game before they had completed the Class-test, i.e. before seeing the specimens of objects which were shown in the class-room. Their answers could show differences from those of pupils who had seen the specimens and completed the "Living or Not Living"` work-sheet.

Since time was limited and the game was new to the pupils, they took part in pairs. The pairs were selected at random by the class-teacher. Each pair of pupils was given an explanation about how to play and was observed while they took part. They filled in one work-sheet together, and if they disagreed about which category an object should be placed into, this was noted on the work-sheet.

The pupils' responses, which they typed in to the computer, were all stored in files on the disk. The contents of all the pupils' files were later examined and transcripts were made of their responses.



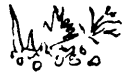
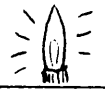
LIVING OR NOT LIVING?

Name _____ Class _____ Age _____

Boy _____

Girl _____

TICK ONE

1. Potato 	2. Clock 	3. Tree 	4. Mould 
5. Sun 	6. Fruits 	7. Crystals 	8. Cow 
9. Plants 	10. Flame 	11. Meat 	12. Battery 
13. Bread 	14. Stones 	15. Leather 	16. Sugar 

READ THIS CAREFULLY:-

Here are some boxes with pictures. The questions all refer to these pictures. The answers to Questions 1, 2, and 3 are just box numbers. For example, if you were asked, which boxes contain something you can eat, the answer would be 1, 11, 13, 16.

Now try to answer the questions.

---

1. Which boxes contain something which is still living?

2. Which boxes contain something which is not living now, but came from a living thing?

3. These things are not living now, but they came from living things which are shown in the boxes. Find these living things and write your answers like this -

Not living now	The living thing it came from

Turn over

4. Some living things are so tiny you cannot see them with your own eyes. You need a microscope.

Which do you think are living things?

tiny animals	
tiny plants	
tiny bits or particles	

Tick one, or more than one, of the boxes.

Now wait until everyone has finished before you start Question 5.

5. I have something in my hand. What questions would you ask me if you wanted to find out if it is alive? Write your questions below.

_____

_____

_____

_____

Make sure you have answered all the questions.

Don't forget to write your name, age and class at the beginning of the sheet!

School Study-Results

Work-sheet: Results of Question One

In answer to Question 1 "Which boxes contain something which is still living?" the following results were obtained for each age group.

Table 5.1 The percentage of pupils, at each age group, who correctly included the living objects as "still living" is as follows:-

No. of Pupils	44	112	130	111	136
Age	7	8	9	10	11
Potato	*29	20	*12	30	*10
Fruits	29	29	31	45	32
Tree	82	**79	91	*93	**95
Mould	*9	17	20	*26	22
Cow	100	97	98	99	99
Plants	**75	*95	90	*93	**96

N.B For each table, * denotes significance between age groups at 5% level, and ** at 1% level. Sub-numerals indicate groups being compared.

Table 5.2 The percentage of pupils, at each age group, who included the other objects as "still living", is as follows:-

Age	7	8	9	10	11
Crystals	**64	*37	**26	**38	**12
Sun	**61	49	50	52	**28
Flame	*34	18	21	24	*18
Sun + Flame	*27	16	15	16	*8
Battery	20	8	15	22	14
Stones	16	5	2	6	1
Clock	*23	11	14	13	*4
Bread	*20	8	9	11	*1
Meat	9	4	5	11	2
Leather	11	4	2	4	1
Sugar	14	4	4	7	2

Question One: Reasons given by pupils

Pupils' reasons for including a non-living object as "still living" in Question 1 are shown below. This further information was obtained by questioning 7 year old pupils during their interviews, and some 11 year old pupils.

The number of pupils questioned was 28 at age 7, and 13 at age 11 (5 from the rural school and 8 from 4 other schools)

Table 5.3

Object	Reasons given by pupil	No. of pupils Age 7	Age 11
Crystals	They grow.	6	5
	Like a plant/from a plant	7	5
	They're in water	10	0
Sun	It shines	4	2
	Gives light/heat	3	4
	Gives us life	3	0
	It moves	2	0
	God made it	1	1
Flame	It burns	2	2
	It's hot	0	2
	It moves	1	1
	It grows	1	0
	It consumes	0	1
Battery	It charges	2	0
	Has power	1	1
	Makes things work	1	1
	'Alive' or 'dead'	0	1
Clock	It moves	2	1
	It tells time	3	0
	Has a battery	2	1
	It rings	1	0

Question One: Objects Included and Omitted

Table 5.4

The following table shows the groups of objects which were given most frequently in response to Question 1 - "Which things are still living?" Objects which were omitted as well as those which were included in responses are shown, and the number and percentage of pupils who gave the response.

Age	Objects Included	Objects Omitted	No. of pupils	Percentage of pupils
7	3,8,9,7	1,4,6	5	12
No.	3,8,7,5	1,4,6,9	4	9
of	3,8,9,5,10	1,4,6	3	7
pupils	1,3,6,8,9,5,10	4	3	7
44	1,3,4,6,8,9	-	0	0
8	8	1,3,4,6,9	12	11
No of	3,8,9,5	1,4,6	8	7
Pupils	3,8,9	1,4,6	6	5
112	3,8,9,7,5	1,4,6	6	5
	3,8,9,7,5,10	1,4,6	6	5
	1,3,4,6,8,9	-	0	0

9	3,8,9	1,4,6	23	18
No. of	3,8,9,5	1,4,6	16	12
Pupils	3,6,8,9	1,4	7	5
130	3,8,9,7	1,4,6	7	5
	1,3,4,6,8,9	-	0	0
10	3,8,9	1,4,6	12	11
No.of	3,8,9,7	1,4,6	7	6
Pupils	1,3,6,8,9	4	6	5
111	1,3,6,8,9,5	4	6	5
	1,3,4,6,8,9	-	1	1
11	3,8,9	1,4,6	43	32
No. of	3,4,8,9	1,6	15	11
Pupils	3,6,8,9	1,4	11	8
136	3,8,9,5	1,4,6	8	6
	1,3,4,6,8,9	-	2	1

Percentage of Boys and of Girls

Table 5.5

For Question 1, the percentage of boys (M) and percentage of girls (F) who included the living objects as "still living" is as follows:-

Age	7		8		9		10		11	
No. of Boys/ Girls	18	26	54	58	71	59	54	57	66	70
	M	F	M	F	M	F	M	F	M	F
Potato	17	38	30**	10**	14	10	26	33	20*	1*
Fruits	28	31	31	26	38*	22*	48	42	41*	23*
Tree	100*	69*	81	81	93	88	91	95	95	94
Mould	6	12	20	14	18	22	17**	35**	21	23
Cow	100	100	98	97	97	98	100	98	98	100
Plants	56*	88*	81	74	93	86	91	95	92	99

Table 5.6 The percentage of boys and percentage of girls who included the other objects as 'still living' is a follows:-

Age	7		8		9		10		11	
Sex	M	F	M	F	M	F	M	F	M	F
Crystals	72	58	46**	28**	27	25	41	35	11	13
Sun	61	62	54*	45*	51	49	52	53	29	27
Flame	33	35	15	21	20	22	24	25	20	17
Sun + Flame	22	31	13	19	18	12	11*	21*	5	11
Battery	22	19	9	7	14	17	24	19	14	14
Stones	11	19	6	5	1	2	2*	11*	2	0
Clock	22	23	7	14	13	15	13	12	5	3
Bread	17	23	9	7	11	7	7	14	2	1
Meat	0	15	4	3	4	5	7	14	5	0
Leather	6	15	4	5	1	3	4	5	2	1
Sugar	11	15	4	5	3	5	0**	14**	5	0

Results of Question 2

In answer to Question 2, "Which boxes contain something which is not living now but came from a living thing?" the following results were obtained.

Table 5.7 The percentage of pupils at each age level who included each object is as follows:-

Age	7	8	9	10	11
No. of Pupils	44	112	130	111	136
No. 13. Bread	36	35	49	40	41
11. Meat	**68 11	*88 7	*89 7	80	**94 7
15. Leather	**23	**61 7	**72 7,11	**63 7	**62 7,9
16. Sugar	**16 9,10,11	**29 9,10,11	**45 7,8,11	**42 7,8,11	**71 7,8,9,10
All the above	0	4	10	13	10
None of the above	7	4	6	8	1
1. Potato	**16 8	**46* 7 11	**56 7,10	**37 7,9,11	**64 7,8,10
6. Fruits	*27 9,10,11	**34 9,11	**52 7,8	*45 7	**54 7,8
4. Mould	25	**32 11	**34 11	29	**15 8,9
1+6 Potato + Fruit	**9 11	**20 11	**34 7,10	*21 9	**42 7,8
1 + 4 Potato + Mould	7	16	**22 11	13	**12 9
1,6,4 Potato Fruit +Mould	4	7	12	6	6
7. Crystals	7	13	17	19	16
3. Tree	0	1	1	0	0
8. Cow	0	0	0	0	0
9. Plants	0	1	1	0	0

Question Two: Objects Included and Omitted

Table 5.8

The following table shows the groups of objects which were given most frequently in response to Question 2 - "Which things are not living now, but came from a living thing?". The number and percentage of pupils at each age level who gave the response is shown.

Age	Objects Included	Objects Omitted	No. of pupils	Percentage of pupils
7	11	13,15,16	9	21
No. of	11,13	15,16	6	14
Pupils:	-	11,13,15,16	3	7
44	11,13,15,16	-	0	0
8	11,15	13,16	11	10
No. of Pupils:	11,15,1	13,16	7	6
112	11	13,15,16	4	4
	11,6	13,15,16	4	4
	11,13,15,16,1,4,6	-	4	4
	11,13,15,16	-	0	0
9	11,13,15,16,1,6	-	12	9
No. of	11,15	13,16	9	7
Pupils:	11,15,16	13	9	7
130	11,15,6	13,16	5	4
	11,13,15,16	-	1	1
10	11,6	13,15,16	9	8
No. of	11,13,15,16,1,6	-	7	6
Pupils:	11,15	13,16	7	6
111	11,13,15,16,1	-	6	5
	11,13,15,16	-	2	2
11	11,15,16,1,6	13	11	8
No. of	11,13,15,16,1,6	-	10	7
Pupils:	11,15,16	13	7	5
136	11,15,1,6	13,16	7	5
	11,13,15, 16	-	4	3

Table 5.9

For Question 2 the percentage of boys (M) and percentage of girls (F) who included each object as "not living now" is as follows:-

Age	7		8		9		10		11	
No of Boys/ Girls	18	26	54	58	71	59	54	57	66	70
Sex	M	F	M	F	M	F	M	F	M	F
Bread	44	31	43**	28**	59**	37**	43	37	45	37
Meat	83	58	87	90	90	88	83	77	91	97
Leather	11	31	65*	*57	77	66	33**	58**	68	73
Sugar	11	19	37**	22**	52*	36*	20*	44*	67	57
All the above	0	0	2	0	3	2	2	4	3	0
None of the above	0	12	6	3	1	12	6	11	0	1
Potato	17	15	43	50	58	54	39	35	59	69

Fruits	33	23	43**	26**	51	54	44	46	45*	63*
Mould	22	27	30	34	41*	25*	31	26	23	9
Potato + Fruits	6	12	24	17	32	36	22	19	32*	51*
Potato + Mould	6	8	15	17	31**	12**	17*	9*	15	9
Potato, Fruits + Mould	0	8	11*	3*	15	8	7	5	6	6
Crystals	17	0	15	12	21	12	19	19	24	9
Tree	0	0	2	0	0	2	0	0	0	0
Cow	0	0	0	0	0	0	0	0	0	0
Plants	0	0	0	2	2	0	0	0	0	0

Results of Question Three

Table 5.10(a)

In answer to Question 3, the percentage of pupils who correctly matched the "once living" objects with the "living objects they came from" is as follows:-

Age	7	8	9	10	11
No. of pupils	44	112	130	111	136
Meat → Cow	64** 11	71** 11	73** 11	70** 11	**91
Bread → Plant	16	11** 11	18	15* 11	**27 8,10
Leather → Cow	18** 9,10,11	35** 11	38* 7,11	38* 7,11	**50 7,8,9,10
Sugar → Plant	2** 9,10,11	13** 11	**25 7,11	*22 7,11	**51 7,8,9,10

Table 5.10(b)

The percentage of pupils who included living objects in Question 2 and applied them in Question 3 are as follows:-

Age	7	8	9	10	11
Potato → Plant	7**	27* 7	34** 7	30** 7	53** 7
Fruit → Tree or plant	9** 9,10,11	26** 9,10,11	44** 7,8	44** 7,8	46** 7,8

Table 5.11

For Question 3, the percentage of boys (M) and percentage of girls (F) who matched the objects are as follows:-

Age	7		8		9		10		11	
Sex	M	F	M	F	M	F	M	F	M	F
Meat→Cow	83*	50*	67*	76*	69	78	57**	82**	83	99
Bread→Plant	17	15	19**	**3	23	14	15	16	29	26
Leather→Cow	17	19	35	34	41	34	37	39	36**	63**
Sugar→Plant	0	4	19*	9*	31*	17*	11**	32**	47	56
Potato→Plant	6	8	30	24	37	31	35*	25*	42*	63*
Fruit→Tree or plant	11	8	30*	22*	44	44	39*	49*	32**	59**

Results of Question Four

Table 5.12

In answer to Question 4,"Which are living things - microscopic animals, plants or particles?" the percentage of pupils who chose each of the 3 categories are as follows:-

Age	7	8	9	10	11
No. of Pupils	44	112	130	111	136
Animals	73	**87 (9, 10, 11)	*72 (8)	**66 (8)	**63 (8)
Plants	**70 (9, 10, 11)	*49** (7, 10)	** 39 (7)	**28 (7, 8, 11)	**47 (7, 10)
Particles	*52 (8)	*71** (7, 9, 10, 11)	*56 (8)	*56 (8)	**54 (8)

Table 5.13

The percentage of boys (M) and percentage of girls (F) who chose each of the 3 categories are as follows:-

Age	7		8		9		10		11	
Sex	M	F	M	F	M	F	M	F	M	F
Animals	72	73	83	90	73	69	69	63	65	61
Plants	56	81	50	48	42	36	28	28	48	46
Particles	50	54	78**	64**	61	51	57	54	56	51

Qu.5 "What questions would you ask to find out if the object in the box is living?"

Table 5.14 The words used by pupils in their responses to Question 5 were grouped into 19 categories - 18 attributes of living things - as follows:-

Attribute	Words used by pupils in their Responses.
1. Movement	Move, walk, crawl, climb, run, jump, fly, wriggle, spin a web,
2. Eating	Eat, feed, food
3. Senses	See, hear, taste, smell, eyes, ears, tongue, nose, mouth, feelers, brain, think, skin ,head
4. Reproduction	What sex is it. Male, female, baby, milk, mother, eggs, lay eggs, seed,
5. Breathing	Breathe
6. Growing	Grow
7. Excretion	Toilet
8. Noise	Talk, bark, cry, make a noise
9. Legs	Legs, how many legs, six legs, eight legs,
10. Four legs	Four legs
11. Fur	Fur, hair, wool, whiskers, feathers
12. Tail	Tail
13. Size	What size, how large, how big, how small, how long.
14. Defence	Bite, attack, dangerous, fierce, claws, sharp claws, sharp teeth, fangs, prickles, horns
15. Habitat	Where does it live? on land, in the sea, where does it come from? What country?
16. Blood	Blood
17. Heart	Heart, pulse
18. Cells	Does it have cells
19. Plant	Plant, leaves, green

Table 5.15

The percentage of pupils at each age level who gave each of the attributes is as follows:-

Age	7	8	9	10	11
No. of pupils	43	112	129	111	136
Movement	**95	**41*	**43*	**43*	**53*
Eating	**47	32	*29	**23	**38
Senses	28	18	30	18	21
Reproduction	19	8	9	7	5
Breathing	5	4**	2**	**5	**18
Growing	5	1	1	2	6
Excretion	2	0	0	0	0
Noise	**42	**5	**11	**6	**8
Legs	**5	**35*	**49*	**36*	**35
Four legs	0*	13	*18	16	9
Fur	2**	16*	**29*	18	*19
Tail	0	10	12	8	6
Size	**0	**38*	**34*	**48*	**26
Defence	9	17	14	15	12
Habitat	**0	**27	**30	**39*	**28*
Blood	0	2	0	2	4
Heart	2	0	0	2	6
Cells	0	0	0	0	1
Plant	-	0	4	3	7

Notes

1. The first 7 attributes listed above are the standard seven biological attributes or characteristics of living things.
2. The pupils aged seven were interviewed and did not use the work-sheet on their own, as the other pupils did.

Table 5.16

The percentage of boys (M) and percentage of girls (F) who gave each of the attributes is as follows:-

Age	7		8		9		10		11	
No. of Boys/ Girls	18	25	54	58	71	58	54	57	66	70
Attribute	M	F	M	F	M	F	M	F	M	F
Movement	94	96	31**	50**	44	43	44	42	50	56
Eating	50	44	35	29	30	29	20	16	35	41
Senses	28	28	11**	24**	38*	21*	19	18	23	19
Reproduction	33	8	11	5	10	9	13**	2**	6	4
Breathing	0	8	6	2	3	2	6	5	12	23
Growing	6	4	2	0	0	2	2	2	6	6
Excretion	0	4	0	0	0	0	0	0	0	0

Noise	44	40	2	9	11	10	9	4	5	11
Legs	0	8	31	38	52	45	39	33	35	36
Four legs	6	0	13	14	10**	28**	13	19	10	6
Fur	0	4	9*	19*	30	29	20	16	26	13
Tail	0	0	7	12	13	12	13*	4*	5	7
Size	0	0	30**	47**	30	40	44	51	29	24
Defence	11	8	11**	22**	17	10	20*	11*	12	11
Habitat	0	0	30	24	30	31	22**	54**	27	29
Blood	0	0	2	2	0	0	0	4	3	6
Heart	6	0	0	0	0	0	4	0	6	6
Cells	0	0	0	0	0	0	0	0	2	0
Plant	-	-	0	0	4	3	6	0	8	7

The Seven Attributes of Living Things - Order of Importance

Table 5.17

The order of importance, at each age level, of the seven attributes of living things is shown below, together with the percentage of pupils who gave each attribute.

Age: 7		8		9		10		11	
Attribute	%	Attribute	%	Attribute	%	Attribute	%	Attribute	%
Movement	95	Movement	41	Movement	43	Movement	43	Movement	53
Eating	47	Eating	32	Senses	30	Eating	23	Eating	38
Senses	28	Senses	18	Eating	29	Senses	18	Senses	21
Reproduction	19	Reproduction	8	Reproduction	9	Reproduction	7	Breathing	18
Breathing	5	Breathing	4	Breathing	2	Breathing	5	Growing	6
Growing	5	Growing	1	Growing	1	Growing	2	Reproduction	5
Excretion	2	Excretion	0	Excretion	0	Excretion	0	Excretion	0

Attributes - Order of Importance

Table 5.18

The order of importance, at each level, of all nineteen attributes is shown below, together with the percentage of pupils who gave each attribute:-

Age: 7		8		9		10		11	
Attribute	%	Attribute	%	Attribute	%	Attribute	%	Attribute	%
Movement	95	Movement	41	Legs	49	Size	48	Movement	53
Eating	47	Size	38	Movement	43	Movement	43	Eating	38
Noise	42	Legs	35	Size	34	Habitat	39	Legs	35
Senses	28	Eating	32	Senses	30	Legs	36	Habitat	28
Reproduction	19	Habitat	27	Habitat	30	Eating	23	Size	26
Defence	9	Senses	18	Eating	29	Senses	18	Senses	21
Breathing	5	Defence	17	Fur	29	Fur	18	Fur	19
Growing	5	Fur	16	Four legs	18	Four legs	16	Breathing	18

Legs	5	Four legs	13	Defence	14	Defence	15	Defence	12
Excretion	2	Tail	10	Tail	12	Tail	8	Noise	8
Four legs	2	Reproduction	8	Noise	11	Reproduction	7	Four legs	7
Fur	2	Noise	5	Reproduction	9	Noise	6	Plant	7
Heart	2	Breathing	4	Plant	4	Breathing	5	Growing	6
Size	0	Blood	2	Breathing	2	Plant	3	Tail	6
Habitat	0	Growing	1	Growing	1	Growing	2	Heart	6
Tail	0	Heart	0	Blood	0	Blood	2	Reproduction	5
Blood	0	Excretion	0	Heart	0	Heart	2	Blood	4
Cells	0	Cells	0	Excretion	0	Excretion	0	Cells	1
Plant	-	Plant	0	Cells	0	Cells	0	Excretion	0

Ranking of the Seven Attributes of Life

Table 5.19

The rank of the seven attributes, when they are ranked with all other attributes from 1 (highest rank) to 19 (lowest rank), are shown below for each age level:-

Attribute	Age				
	7	8	9	10	11
Movement	1	1	2	2	1
Eating	2	4	6	5	2
Senses	4	6	4	6	6
Reproduction	5	11	12	11	16
Breathing	8	13	14	13	8
Growing	8	15	15	16	14
Excretion	11.5	17.5	17.5	18.5	19

Results of Computer Game

1. Table 5.20

The following table shows the results from the small work-sheet "Alive or Not Alive" which pupils had to complete in pairs before they played the game.

The number of pairs which included each object as "living" or "not living" are shown. The total number of pairs was 19.

Object	No. of pairs which included object as	
	Living	Not Living
Rabbit	14	0
Spider	12	0
Apple	3	9
Flame	7	4
Battery	3	10
Crystals(1)	0	4
Crystals(2)	5	2

Note Crystals (1) - Group 1 pupils have not completed Class work-sheet nor seen the specimens.

Crystals (2)- Group 2 pupils have completed Class work-sheet and seen the Crystal garden.

Table 5.21

In some cases, a pair of pupils was unsure about which category an object should be placed into, and there was some discussion between the two pupils until a final decision was made. This is shown below:-

Object	No. of pairs	Final decision
Apple	1	Not living
Flame	1	Living
Battery	2	Not living
Crystals(2)	1	Living

Note: These results are included in the first Table above.

2. Questions Asked by Pupils

Table 5.22

The questions asked by the pairs of pupils and typed in to the computer about the different objects are shown below, and the number of times each question was used.

Object	Question Asked	Previous Object(s)	No. of times
Rabbit	Does it have long ears.	Mouse or spider	9
	Does it have a long, thin tail.	Mouse	3
	Does it hop.	Mouse	1
	Is it big.	Spider	1
Spider	Does it have 8 legs.	Mouse or rabbit	8
	Does it spin a web.	Flame	1
	Does it have 4 legs.	Mouse	1
	Does it have a tail.	Mouse	1
	Is it black.	Rabbit	1
Apple			Living
	Is it a green fruit	Rabbit	1
	Has it stones or seeds	Rabbit	1
	Does it grow on trees	Mouse	1
			Non-Living
	Can you eat it	Battery Flame or Crystals	7
	Is it hard	Rabbit	1
	Is it soft	Rabbit	1

Flame			Living
	Is it hot	Rabbit, Spider	2
	Does it burn	Crystals, Mouse	
		Spider	4
	Does it give light	Crystals	1
			Non Living
	Is it hot	Stone, Apple	3
	Does it burn	Crystals	1
	Does it move	Stone	1
	Does it have carbons in it.	Stone	1
Battery			Living
	Does it give power	Crystals	2
	Does it make things work	Spider	1
			Non Living
	Does it make things work	Crystals, Apple	4
	Is it a source of power	Crystals, Stone	3
	Is it useful	Stone	1
	Does it make electricity	Crystals	1
	Is it round or cylindrical	Stone	1
			Living (All Crystals 2)
Crystals	Can it move	Apple	1
	Are they hard	Flame	1
	Are they made of stone	Flame	1
	Is it like thread	Flame	1
	Do they grow in water	Spider	1
			Non-Living
	Is it clear	Apple	2
	Is it shiny	Flame	1 } Crystals (1)
	Does it sparkle	Apple	1
	Are they round	Stone	1 } Crystals (2)
	Are they hard	Apple	1

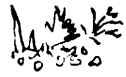
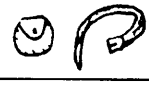
LIVING OR NOT LIVING?

Name _____ Class _____ Age _____

Boy _____

Girl _____

TICK ONE

1. Potato 	2. Clock 	3. Tree 	4. Mould 
5. Sun 	6. Fruits 	7. Crystals 	8. Cow 
9. Plants 	10. Flame 	11. Meat 	12. Battery 
13. Bread 	14. Stones 	15. Leather 	16. Sugar 

READ THIS CAREFULLY:-

Here are some boxes with pictures. The questions all refer to these pictures. The answers t
Questions 1, 2, and 3 are just box numbers. For example, if you were asked, which boxe
contain something you can eat, the answer would be 1, 11, 13, 16.

Now try to answer the questions.

---

1. Which boxes contain something which is still living?

2. Which boxes contain something which is not living now, but came from a living thing?

3. These things are not living now, but they came from living things which are shown in the boxes. Find these living things and write your answers like this -

Not living now	The living thing it came from

Turn over

4. Some living things are so tiny you cannot see them with your own eyes. You need a microscope.

Which do you think are living things?

tiny animals	
tiny plants	
tiny bits or particles	

Tick one, or more than one, of the boxes.

Now wait until everyone has finished before you start Question 5.

5. I have something in my hand. What questions would you ask me if you wanted to find out if it is alive? Write your questions below.

_____

_____

_____

_____

Make sure you have answered all the questions.

Don't forget to write your name, age and class at the beginning of the sheet!

Chapter 6

Interpretation of School Study Results

Contents

Question One: Objects which are still Living

(a) Living Things (Table 5.1)

A significantly high percentage of children at every age level included Cow, Plants and Tree as being living. Results for Cow are very similar for all age groups and show that over 95% of children, aged 7 to 11, believe that a Cow is a living thing. All of the children in the Pilot Study were sure that animals were living.

There are significant differences between the age groups for Tree and Plants. Higher percentages of 10 and 11 year olds, compared to 8 year olds, have included Tree as being living, although all results for Tree are over 75%. Children of 8 will not have learned as much about trees as children aged 10 and 11, and more 8 year olds are not sure that a tree is living. So a slight development in the concept of life is apparent from these results.

For Plants, a significantly lower percentage of children aged 7 have included them as being living compared to percentages at other age levels, except age 9. Children of 7 probably find it more difficult than older children to imagine a plant, which, unlike a tree, can have many different forms. They also will not be as familiar with plants, or as interested in them, as children of 10 or 11 who will have learned more about plants. There must be a development in understanding after age 7, and most children aged 8 to 11 have included Plants as living.

At every age level, the percentages for Mould, Potato and Fruits are much lower than the percentages for Cow, Tree and Plants and results are fairly uniform across the age bands.

Many children are unsure that Mould is living: the highest percentage is 26% at age 10, which is significantly higher than 9% at age 7. This shows that there is an increase in the understanding of children at age 10 regarding living things, but all percentages for Mould are very small. Most children in the Pilot Study classed Mould as non-living, and they found difficulty in suggesting life-attributes for it.

Results for Potato are not above 30%. The percentage at age 7 is significantly higher than the percentages at ages 9 and 11. Many children, even at age 11, do not have a concept of dormant life or of static life. Children aged 7, however, are more inclined to say that a potato is living than the older children. This agrees with the results from the Pilot Study where most children had no doubts about animals and plants being living but were uncertain about mould, fruits and vegetables. If they cannot give any living attributes to an object, then children tend to say that it is not living, or, in the case of a fruit or a vegetable that it was living at one time. Percentages for Fruit are similar at all age levels, and are similar to the results for Potato.

(b) Non-living Things (Table 5.2)

Significant differences between the age bands are present for several non-living objects, as follows.

The percentage of 7 year olds who included Crystals is much higher than the percentages for all other age bands e.g. six times higher at age 7 than at age 11. This indicates that there is a change in childrens' ideas about crystals after age 7.

Children think that crystals are living because of their likeness to plants and because they grow. Probably more children of 8 and upwards have a greater understanding of growth than younger children, and older children know that crystals are not growing in a biological sense and therefore cannot be living. At age 11, children are less likely to be deceived by the plant-like appearance of crystals and they have a more mature understanding of what is living and what is not living than younger children.

For both Sun and Flame the percentage at age 7 is significantly higher than the percentage at age 11. In addition, the percentage of 7 year olds who included both Sun and Flame in their answer is significantly higher than the percentage at age 11.

Children of 7 believe that the sun is living because of simple, animistic ideas. They know that the sun moves and shines, and these attributes are indicators of life at this age. At

age 11, most children have more sophisticated ideas and will have learned something about the sun as a planet. They are less likely to attribute life to it, although some 11 year olds have retained the belief that the sun is living, and their reasons are the same as those of 7 year olds. (Table 5.3)

The attributes which children give to a flame are possession of heat and movement; these attributes are indicators of life to many 7 year olds and to a small percentage of 11 year olds. Since both Sun and Flame have similar attributes in childrens' minds, this explains why a higher percentage of 7 year olds, compared to 11 year olds, included both objects. Percentages for Sun at every age level are much higher than those for Flame and for the Sun/Flame combination. This means that children more readily attribute life to the Sun than to a flame.

About 50% of children in the age groups 8,9 and 10 still believe that the sun is living and their ideas have not changed since age 7. Since the percentage who included Sun as well as Flame is less than the percentage for Sun, the attributes of heat, light and movement cannot be the only ones which children give to the Sun. The idea of the Sun giving life may cause more children to believe that it is living.

Age 7

Higher percentages of children included Crystals and Sun compared to any other non-living object, including Flame, Battery and Clock, but these differences may not be significant. This agrees with the Pilot Study results where Crystals and Sun were included by several children of all ages, while Battery and Clock were included by only a few children. Many children of 7 have included Crystals and Sun because these objects can be given attributes of life more easily than other objects can.

For both Clock and Bread the percentage at age 7 is significantly higher than the percentage at age 11. Children of 11 will have a more developed concept of life than children of 7, and only small percentages of 11 year olds have included Clock, Bread and other non-living objects as being living. They have retained their naive ideas about certain objects and have not yet realised that these beliefs are false. In the Pilot Study children said that a clock is living because "it goes" or "it works"; only children of 6 and 7 included it as living.

Meat, Bread, Leather, Sugar

The percentages of children who included these objects as being living are all very low. Children who did include them may have done so for a number of reasons:-

because they come from living things,

because some children include every object as being living,

because children think that any food is living.

The higher percentage for Bread at age 7 could be because 7 year olds are more likely to include objects for these reasons than 11 year olds are.

These results (Tables 5.1 & 5.2) show that there are some children at every age level from 7 to 11 who do not have a correct concept of life and who attribute life to a non-living object. At every age level, a similar percentage of children believe that e.g. a battery, stones and meat are living. The very small percentages of children who included Stones either believe that everything in the environment is living or they are perhaps associating Stones with Crystals.

(c) Pupils' Reasons for Including Non-Living Objects

From Table 5.3, the reasons given by 11 year olds are the same as those of 7 year olds. This means that some older children have retained their naive ideas, e.g. Crystals grow, therefore they must be living, or Crystals "look like" plants and must be living. Many 7 year olds said that crystals are living because they are "in water". Perhaps this phrase suggests flowers or plants to children, because they will be familiar with cut flowers being placed in water.

Sun and Flame

The reasons which were given for Sun are that it shines and gives light. The idea of it "giving life" comes only from 7 year olds but this reason would probably be given by children of 8 to 10 as well.

For Flame, the reasons include "it burns", "is hot" and "it moves". "It consumes" is a sophisticated and original idea from an 11 year old.

Battery, Clock

Pupils of both ages included Battery because it has "power" and "makes things work". The influence of language did not seem to be as important as these reasons. The 7 year olds' reasons for including Clock were more simple than those of the 11 year olds e.g. "it tells time"

and 'it rings.' Movement is probably the main attribute that causes children to say that a clock is living.

The reasons given by these 41 children in the schools are almost the same as the reasons which children gave during the Pilot Study when these objects were discussed. These results should help to explain why children in the large sample included non-living objects as being living.

(d) Groups of objects most frequently included/omitted

(Table 5.4)

Children most frequently included the three living things Cow, Tree and Plant (8,3,9) in Question 1, and frequently omitted Potato, Fruits and Mould (1,6,4). Crystals (7) and Sun (5) were the two most frequently included non-living objects, with Flame (10) also appearing often at age 7 and 8. Even at age 10 and 11, children frequently omit objects like Potato and Mould from the living category and the most frequent response is Cow, Tree and Plant, just as it is at age 7 and 8. Crystals (7) appears less at age 11, however, than in the younger age groups. Only 1% of pupils at each of the ages 10 and 11 included the six correct objects alone, and have a complete concept of life. Other pupils also included them together with non-living objects. These results demonstrate in another way how the School results are in agreement with the Pilot Study results.

(e) Sex Differences (Tables 5.5 & 5.6)

Generally the percentages for boys are similar to the percentages for girls in Question 1, but there are some significant differences.

1. Living Things (Table 5.5)

Significant differences at age 7 for Tree and Plants

age 8 for Potato,

age 9 for Fruits,

age 10 for Mould,

age 11 for Potato and Fruits.

(i) Age 7

88% of girls included Plants compared to only 56% of boys. It has been suggested already that children of 7 are less familiar with plants or are not as interested in them as older children, and a lower percentage included them as being living. Perhaps, at age 7, fewer boys

than girls are interested in plants. Girls tend to be more attracted to flowers and plants than boys, and this may explain the difference in percentage.

Only 69% of girls included Tree as being living compared to 100% of boys. Girls of 7 may not have as great an interest and physical awareness of trees as boys do, because of the different types of recreation which boys engage in.

The method of testing the 7 year olds, i.e. interviewing them in pairs, which consisted usually of a boy and a girl, may have had an effect on the results. There may be an intuitive association of plants with girls and trees with boys. Thus the boys may have stated more readily that trees are living, and this has caused fewer girls to express their belief. Similarly more girls than boys would state that plants are living.

(ii) Age 8

30% of boys included Potato as being living compared to only 10% of girls. Perhaps, at age 8, more boys than girls have come across potatoes as a crop which is harvested, and they have learned that potatoes grow on a plant and therefore must be living. Girls of 8 are not as likely to be interested in potato-growing but they will think of the potato as a food.

(iii) Age 9

38% of boys included Fruits as being living compared to 22% of girls. The reason for this difference may be similar to the reasons above for Potato at age 8. Boys of 9 are more likely to think of Fruits as growing on plants whereas girls think of Fruits as foods.

(iv) Age 10

35% of girls included Mould compared to only 17% of boys. This indicates that more girls than boys have a concept of static life at age 10. More girls are able to class an object like Mould, which does not have obvious attributes such as movement, as being living.

(v) Age 11

20% of boys included Potato as being living compared to only 1% of girls. The reasons for this difference could be the same as those for 8 year olds above. Also more girls of 11 than boys included Potato as being "not living now but living at one time". More girls of 11 tend to think of a potato as coming from a living thing, but not in itself living. So the girls do not have as strong a concept of dormant life as boys of 11 do.

Also 41% of boys included Fruits as being living compared to only 23% of girls. Again, more girls aged 11 than boys included Fruits in the "not now living" category. The

girls tend to think of Fruit as a product of a living thing and this affects their concept of life and causes them to exclude certain living objects.

2. Non-living Things

Significant differences are at age 8 for Crystals and Sun and age 10 for Sun/Flame, Stones and Sugar.

(i) Age 8

46% of boys included Crystals as being living compared to 28% of girls. At age 8 more boys than girls have incorrectly classified Crystals as being living. Maybe more of the boys know about crystals growing and have encountered them before. The main reasons that children gave for crystals being living were that they "grow", and they look like plants.

54% of boys included Sun as being living compared to only 45% of girls. Perhaps more boys compared to girls are aware of the "movement" of the sun and this has caused more of them to class it as living. Girls of 8 will not be as interested in the sun and in planets as boys will be, and more of the boys will have thought about the sun giving light and heat. In this way, more of the boys believe that it is living.

(ii) Age 10

21% of girls included Sun and Flame in combination, compared to only 11% of boys. There were no differences between the sexes for either of the two objects when taken individually. It seems that more girls of 10 than boys have in their minds a link between Sun and Flame because of the similar attributes which both objects have. More of the girls think that both the sun and a flame are living because they both have the attributes heat, light and movement.

11% of girls included Stones as being living compared to only 2% of boys. It may be that, at age 10, many girls attribute life to objects in the environment including stones. However, it is not known why this difference between the sexes only appears at age 10. Not one boy of 10 included Sugar as being living but 14% of girls did include it. Once again, more girls than boys have included a non-living object, which does not have any obvious attributes of life, as being living. Perhaps the girls who included it did so because they are linking it with crystals which they may have classed as being living. They may also have classed stones as being living for the same reason.

Question 2: Objects which were Living at One Time

(a) Objects correctly included Table 5.7

Bread

There are no differences in percentages between the age bands and all results are below 50%. Many children do not view bread as something which comes from a living thing, i.e. a plant. In the Pilot Study only two children said that bread was living at one time: one child added that it is made of wheat which is living.

Meat

Meat provoked a different response and the percentages are all higher than those for Bread. Animals seem to be more important in childrens' minds than plants and they can perhaps relate Meat to a living animal more easily than they relate Bread to plants, even at age 10 and 11. Over 90% of children aged 11 have included Meat. At ages 8, 9 and 11, a significantly higher percentage have included it than at age 7. More of the older children have a concept of things which were once living and of animal origin than the 7 year olds. Children aged 10 appear to be out of step with adjacent age levels: they may be reasoning too much and be arriving at a wrong conclusion.

Leather

The percentage at age 7 is significantly less than the percentages at all other age levels. It seems that 7 year olds find it more difficult to think of leather as an object which came from a living thing than the older children do. In the Pilot Study most children classed leather correctly, but some children aged 7 and under did not know where it came from.

The percentage at age 9 is significantly higher than the percentage at age 11. This shows that there is not an increasing awareness of leather as an object of animal origin from age 9 to age 11 and fewer children of 11 have placed leather in the correct category compared to children aged 9.

The results for Leather are lower than those for Meat. This could be because children are more familiar with Meat and its origin from their daily life, but they are not so familiar with Leather, even at age 10 and 11. Many children apparently do not know that it comes from animals.

Sugar

In this case, the percentage of 11 year olds who included Sugar in the correct category

is significantly higher than the percentages at all other age levels. Also both the percentage at age 7 and the percentage at age 8 are significantly less than the percentages at age 9 and age 10. This shows that there is a gradual increase in understanding and an increase in ability to place Sugar in the correct category, as children increase in age, until a high percentage of 11 year olds include Sugar.

Percentages are all lower than those for Meat and, except at age 11, for Leather. Sugar and Meat are both foods with which all children are familiar, and at age 11, most children will know where these objects come from. Most children are not as certain about the origin of Bread and Sugar as they are about the origin of Meat.

Age 11

The percentage for Bread is much lower than the percentages for the other three objects. This may be because children are thinking of bread as being made from flour or grain, and they have not traced it back to wheat growing in a field. This may explain the low percentages for Bread at other age levels too.

Complete concept

Only 1-3% of children, in the age range 9 to 11, included only the four correct objects and have a complete concept of objects which come from living things. A very small percentage of children at each age level included none of the four objects in their answer; they do not have a concept of objects which come from living things.

(b) Living Things Incorrectly Included (Table 5.7)

The living things which children included in the category "not living now, but came from a living thing" were mostly Potato, Fruits and Mould. Not one child included Cow and a negligible percentage at ages 8 and 9, included Tree and Plants, maybe by mistake. Most children are certain that animals are still living and a high percentage are certain that plants are. The percentages for Potato, Fruits and Mould are all less than 60%, except at age 11 for Potato.

Potato

A significantly lower percentage of children aged 7 included Potato compared to children at all other age levels. The much lower percentage at age 7 does not imply that most 7 year olds have a concept of dormant life, because only a small percentage of them included Potato as being living in Question 1. Most of them are probably unsure about how to class

Potato and therefore have decided that it is not living.

The percentage at age 11 is also significantly higher than the percentages at ages 8 and 10. So a high percentage of 11 year olds do not have a concept of dormant life and many believe that a potato is not living but that it comes from a living plant. In addition, only a small percentage of them included it in Question 1. Although they will have learned more about plants and living things than younger age groups, many of them still incorrectly categorise Potato. In the Pilot Study several children said that a potato was living when it was in the ground or in soil, but not when it is removed from the plant.

Once more, 10 year olds appear to be "out of step" because the percentage at age 10 is significantly lower than the percentage at age 9. At ages 8 and 10, childrens' ideas, whether they are erroneous or not, are not as developed as those of 11 year olds, therefore the percentages are lower. The percentages for the age bands 8 to 11 are greater than the percentages for the same age bands in Question 1. There must be some children who do not know how to class Potato and who have neither included it in Question 1 nor in Question 2.

Fruits

There is no significant difference between the percentage at age 7 and the percentage at age 8. Percentages for these two age levels are both significantly less than the percentages at age 9 and at age 11. The percentage at age 7 is also significantly less than the percentage at age 10. Once more, it is clear that many children do not have a concept of dormant life and, at age 9 and age 11, over 50% have included Fruit in the category "not living now". In addition, the percentages for Fruits in Question 1 were rather low for all age levels.

More children of 9, 10 and 11 will have learned about fruits and seeds than children of 7. Yet the older children do not think that these objects are living because they are removed from the plant and are not growing, as the Pilot Study results showed. Most 7 year olds probably think that fruits are not living; they will not have learned very much about fruits and will know them mainly as foods.

Potato/Fruits

The percentages of children who included both objects are fairly low. There are significant differences between age 11 and ages 7 and 8. The percentage at age 10 is significantly less than the percentage at age 9, which is higher than the percentage at age 7. Again this shows a progression with increasing age and the 10 year olds are once more "out of

step". This adds further weight to the idea that many children, even at age 11, do not have a concept of dormant life and that many have erroneous ideas about these two objects. Children of 10 do not appear to have a more developed understanding than younger children.

Mould

The percentages for Question 2 are higher than the percentages for Mould in Question 1, except at age 11, indicating that more children believe that mould is "not living now" than believe that it is living. Some children may have thought that mould is found on living things but is itself not living. However, all children were shown a specimen of mould in the class-room and did not have to imagine what it looks like. It would seem that a fairly large percentage of children think that mould is not living, since the percentages in Question 1 were small.

The percentage at age 11 is significantly lower than the percentages at ages 8 and 9. This shows that more children of 8 and 9, compared to children of 11, have the erroneous idea that mould is not living but that it comes from a living thing. At age 11, most children either class Mould as living or think that it is not living.

At age 11, the percentage for Mould is much lower than the results for both Potato and Fruit. This indicates that Mould is viewed as a different form of life from the "life" of a fruit or vegetable. Children are not familiar with Mould and most of them do not consider it to be a living thing. In addition, most children of 11 who included Potato and Fruits did not also include Mould: only 6% included the three objects. At other ages percentages are equally small for inclusion of all three objects. For Potato and Mould in combination, the percentage at age 11 is significantly lower than the percentage at age 9 only, which agrees with the above results for Mould alone.

(c) Crystals

A small percentage of children at every age level included Crystals in Question 2. Perhaps they were thinking that crystals looked like plants growing or seeds sprouting. So they would have the idea that crystals are not living at present, but that they came from plants in the same way that seeds do.

(d) Groups of Objects Most Frequently Included/Omitted

Table 5.8

Meat (11) is the most frequently included object at every age level. A high percentage

of children understand that it comes from a living thing i.e. an animal, but many children are not as certain about including the other objects. Children aged 7 did not give as great a variety of objects in their responses as older children. They generally found Question 2 more difficult than older children, even although they were interviewed in pairs. To answer this question correctly, a child is required to take several steps of reasoning and there will be some children at every age level who will not be capable of doing this. A child has to find objects which meet two requirements - they are not living now and secondly they come from a living thing. At age 7, many children are able to pick out Meat, but it is more difficult for them to find other objects, like Leather or Sugar. (15,16). No child of 7 or 8 included the four correct objects.

At age 8, Meat (11) and Leather (15) were most frequently included, as well as Potato (1). Fruits (6) and Mould (4) were included with the four correct objects.

For ages 9 up to 11, the four objects were most frequently included together with Potato (1) and Fruits (6). Mould (4) was not frequently included, even at age 11. A few children (2-3%) aged 10 and 11, correctly gave only the four objects. At age 11, Potato and Fruit were frequently included with three or four correct objects.

(e) Sex differences

There are several significant differences between the percentages for boys and those for girls. They are at age 8 for Bread, Leather, Sugar, Fruits, Potato/Fruits/Mould; age 9 for Bread, Sugar, Mould, Potato/Mould; age 10 for Leather, Sugar, Potato/Mould; age 11 for Fruits and Potato/Fruits.

(i) Age 8

At this age, the percentages for boys are higher than the percentages for girls for every object concerned. For the objects Bread, Leather and Sugar, more boys than girls have a correct concept of things which are not now livng. It seems that, at age 8, boys are more able to class these objects correctly than girls are.

For Fruits and Potato/Fruit/Mould combination more boys than girls have an incorrect concept of dormant life and more boys than girls have placed these objects incorrectly in the "not living now" category. It could also be that boys find it easier than girls to answer Question 2, and to select objects which come from living things.

(ii) Age 9

Once more, the percentages for boys are higher than the percentages for girls for the objects concerned. For Bread and Sugar, more boys than girls have classed them correctly. Meat and Leather have higher percentages for boys as well, but these are not significantly higher. So, at age 9, more boys than girls have a correct concept.

For Mould and Potato/Mould more boys compared to girls have placed the objects in the wrong category. There was no difference between the sexes for Mould in Question 1, which indicates that it is not true that more boys than girls can place Mould in the correct "living" category.

(iii) Age 10

For Leather and Sugar, the percentages for girls are higher than the percentages for boys. More girls of 10 than boys have placed these two objects in the correct category. This result is different from the results for age 8 and, in the case of Sugar, for age 9 as well. Since the 10 year olds have been "out of step" with the results of adjacent age levels on more than one occasion, this result could be another example of this discrepancy. It may be that at age 10 more girls than boys can answer Question 2 correctly and can select the correct objects.

For the Potato/Mould combination the result is the same as the result for age 9 and the percentage for boys is higher than the percentage for girls. In Question 1, a higher percentage of girls compared to boys aged 10 included Mould, and the percentages for Potato were not significantly different. It seems that more girls than boys have included Mould as being living and therefore more of them have a concept of static life. This would also explain the result for Potato/Mould in Question 2.

(iv) Age 11

The percentages of girls are higher than the percentages of boys for Fruits and the Potato/Fruits combination. This means that more girls than boys have incorrectly classed these objects as being "not living now, but came from a living thing". Perhaps the girls are more aware of fruit as a product of a living plant than boys are. The boys may be more aware of the growth and harvesting of fruits and potatoes. In Question 1 the percentages for boys were higher than the percentages for girls for both the objects Potato and Fruits. So more boys of 11 than girls have a correct concept of dormant life, and this is borne out by the above result for Question 2.

Question 3: Matching of Objects

(a) Matching an Object to the Living Thing it came from

Table 5.10 (a)

Meat→Cow

The result for age 11 is over 90% and is significantly higher than the result at all other age levels. This shows that there is an increase in understanding at age 11, and most children of this age are able to match a non-living object of animal origin to the living thing from which it comes. The percentages at the other age levels are fairly high which shows that a high percentage of children, even at age 7 or 8, understand the relationship between Meat and Cow and can correctly match the two objects.

Bread→Plant

The percentages are all fairly low and the percentage at age 11 is significantly higher than the percentages at age 8 and age 10. Children of all ages do not have an understanding of bread coming from a living plant in the same way that they understand meat coming from a cow. They are probably thinking that bread comes from flour or grain which they are classing as non-living.

However, at age 11 more children are able to match Bread to Plant compared to children aged 8 and 10. So there is again an increase in understanding at age 11, and there is not a gradual increase as children increase in age.

Leather→Cow

The percentages are higher than those for matching Bread → Plant but they are not as high as the percentages for matching Meat → Cow. Many children are not able to match Leather to Cow and are not as familiar with the origin of leather as they are with the origin of meat. However there is again an increase in understanding at age 11, where the percentage is significantly higher than the percentages at ages 7 and 8 (1%) and ages 9 and 10 (5%). This is similar to the increase at age 11 for matching Meat and Bread.

Sugar → Plant

The percentages are fairly low, except at age 11, and are much smaller than the percentages for matching Meat to Cow. Many children are not familiar with the origin of sugar and cannot match it correctly. At age 11 the percentage is significantly higher than the percentages at all other age levels and the percentage at age 7 is significantly less than the

percentages at ages 9, 10 and 11. Once more, there is an increase in understanding at age 11, and 50% of children at this age are able to match Sugar to Plant. More children of 11 compared to younger children will know where sugar comes from. Children of 7 are more familiar with animals than they are with plants, and they would find it more difficult to match Sugar, compared to older children.

In addition, Question 3 would be more difficult for children of 7 and 8 to understand, compared to children aged 11. Children firstly had to pick out the objects which were "not living now" for Question 2, then they had to understand what Question 3 was asking them to do. Finally they had to correctly match the objects. The 7 year olds received extra help and guidance, but they generally found Question 3 difficult to understand, apart from the matching of Meat and Cow. Meat is the first object of the four which they will become aware of and learn about, and it is relatively easy for them to say where it comes from. As children grow older more of them are able to correctly match meat to cow, until at age 11 nearly every child can do this correctly. However, children at every age level seemed to have more difficulty in matching the other three objects.

(b) Living Things Wrongly Matched Table 5.10 (b)

The living things which were most frequently matched were Potato and Fruits. Children who believed that these objects are not living at present matched them to the living things 'Plant' or 'Tree'. These matches are correct as they stand by themselves, but they expose the erroneous ideas which some children have about certain living things. The results confirm the previous results for these objects in Question 2.

Potato → Plants

The percentages correspond to the percentages of children who included Potato as "not living now" in Question 2. These children are answering Question 3 with their belief that a potato is not living and that it comes from a living plant. The percentage at age 7 is significantly lower than the percentages at all other age levels. This also relates to the lower percentage of 7 year olds who included Potato in Question 2. Older children have more developed ideas and have more sophisticated knowledge than children of 7, even if the ideas are erroneous. Children of 7 would also find Question 3 more difficult to understand than older children.

Fruit → Tree/Plants

In a similar way, the percentages correspond to the percentages of children who included Fruits as "not living now" in Question 2. At each of the age levels 9, 10 and 11, the percentage is significantly higher than the percentages at age 7 and at age 8. The older children have a more developed understanding of fruits than children of 7 or 8 have, but even at age 10 and 11, many children do not have a concept of dormant life and they do not think that fruits and vegetables are living.

(c) Sex Differences (Table 5.11)

There are several significant differences between the percentages of boys and the percentages of girls. They are as follows:-

Age	Objects	Significantly higher
7	Meat → Cow	Boys
8	Meat → Cow	Girls
	Bread → Plant	Boys
	Sugar → Plant	Boys
	Fruit → Tree/Plant	Boys
9	Sugar → Plant	Boys
10	Meat → Cow	Girls
	Sugar → Plant	Girls
	Potato → Plant	Boys
	Fruit → Tree/Plant	Girls
11	Leather → Cow	Girls
	Potato → Plant	Girls
	Fruit → Tree/Plant	Girls

(i) Age 7

In Question 2 for Meat, the percentage of boys is also higher than the percentage of girls, but the difference is not significant. In Question 3, more boys compared to girls aged 7 are able to correctly match Meat to Cow. It seems that more boys than girls are aware of the origin of meat.

(ii) Age 8

For the pairs of objects Bread → Plant and Sugar → Plant the results correspond to the results for Question 2, where a significantly higher percentage of boys included Bread and Sugar. In Question 3 a significantly higher percentage of boys are able to correctly match these objects. For the pair Meat → Cow, the percentage of girls is significantly higher than the percentage of boys. This is a complete reversal of the situation at age 7. At age 8 more girls than boys have correctly matched Meat to Cow. The method of testing the 7 year olds, i.e. individual interviewing, may have affected the results, and children of 7 found Question 3 rather difficult to understand.

The percentage of boys is significantly higher for the pair Fruit → Tree/Plant, and this once more corresponds to the result for Question 2, where more boys than girls included the objects Fruits and Potato/Fruits/Mould.

(iii) Age 9

For the pair Sugar → Plant the higher percentage of boys compared to girls corresponds to the result for Question 2, where more boys than girls included Sugar. It seems that more boys compared to girls are aware of the origin of sugar and can correctly match it to Plant. Perhaps more boys than girls have read about the origin of sugar.

(iv) Age 10

The significantly higher percentage of girls for the pair Sugar → Plant corresponds to the significantly higher percentage of girls who included Sugar in Question 2. This is a reversal of the situation at age 9, but the 10 year olds often seem to be "out of step" with adjacent age levels. At age 10 more girls than boys are aware of the origin of sugar.

For the pair Meat → Cow, the percentage of girls is significantly higher, which is the same as the result at age 8. More girls, aged 10, than boys are able to correctly match Meat to Cow; girls are perhaps more aware of the origins of foods than boys are, or maybe the boys are reasoning too much and thinking that meat comes from other animals as well.

The significantly higher percentage of boys for the matching of Potato to Plant corresponds to the higher percentage of boys in Question 2 for Potato/Mould. More boys than girls have the erroneous idea that a potato is "not living now", but comes from a living thing. The result for Question 3 shows that they do have this belief, because they have matched Potato to a living thing.

For the matching of Fruit to Tree/Plant, the percentage of girls is significantly higher. In this case, more girls aged 10 than boys have the erroneous idea that fruit is not living but that it comes from a living thng. i.e. Tree or Plant.

(v) Age 11

A significantly higher percentage of girls matched Leather to Cow. The percentage of girls at age 11 is also higher than the percentages at other age levels for this pair. Girls of 11 will be more knowledgeable about the origins of leather, because of its use in clothing, than boys are. Since there is no difference between the sexes for matching the other three objects, the differences cannot be due to a difference in understanding or ability between boys and girls. The actual objects which are matched must be important in determining differences in response.

For the pairs Potato > Plant and Fruit to Tree/Plant the percentage of girls is significantly higher than the percentage of boys. These results correspond to the results in Question 2 where a significantly higher percentage of girls included Fruits and Potato/Fruits in combination. These objects were matched in the belief that Potato and Fruits are not living but come from a living thing. So more girls of 11 than boys have an incorrect concept of dormant life. Perhaps girls have a greater intuitive understanding of reproduction and the bearing of fruit than boys do at this age. The girls may also have more awareness and knowledge of reproduction in both animals and plants than the boys do. However, as these results show, this does not mean that more girls have a complete concept of dormant life. In addition, a significantly higher percentage of boys correctly included Potato and Fruits as being living in Question 1.

Question 4: Microscopic Living Things (Table 5.12)

Children were asked to tick one or more than one box if they thought that the microscopic things were living.

(a) Children who ticked the "Animals" box

The percentages were generally high compared to the percentages for Plants and Particles. This means that a high percentage of children at every age level think that microscopic animals are living things. Pictures of some specimens were shown to the children to make sure that they knew what the tiny animals look like. At age 8 the percentage

is significantly higher than the percentages at ages 9, 10 and 11. Perhaps children aged 8 are more familiar with animal life compared to plant life and a high percentage are certain that microscopic animals are living. The older children have thought more about different forms of life and they may have tried to find attributes for microscopic animals: some of those children would therefore be unsure whether to tick the animals box or not.

(b) Children who ticked the "Plants" box

At the age levels 8, 9 and 10 percentages are much lower than the percentages for Animals. This is probably because most children are not as familiar with plant life as they are with animal life. Many of them will not have heard about microscopic plants before and they do not view them as living things. At age 11 the percentage is similarly low.

However, at age 7, a significantly higher percentage ticked Plants compared to all the other age levels. The interviewing technique may have affected the results but the 7 year olds were shown the same pictures and were asked the same questions as older children were asked. The microscopic plants shown in the pictures had a flower-like appearance and this may have caused more children of 7 to include them as being living, because their concept of a plant is limited and simply means "flowers". Also plants seem to be of more importance and interest to girls than to boys at age 7. However, there is no significant difference between the percentage of boys and the percentage of girls for ticking "Plants" in Question 4, although the percentage of girls is much higher.

The percentages at age 8 and at age 11 are both significantly higher than the percentage at age 10. Many children of 8 may have ticked "Plants" for the same reason as the 7 year olds, i.e. because of their flower-like appearance. At age 10, more children will know about microscopic plants and many will have encountered them in books or on television. However, many 10 year olds are unsure that microscopic plants are living. Perhaps they have reasoned too much and have thought about the question more than children of 8 have. A high percentage of 10 year olds, therefore, have arrived at the wrong conclusion about microscopic plants, and have an incomplete concept of microscopic life.

At age 11, many children will also know about microscopic plants and they will probably understand microscopic life better than children of 10. This explains why the percentage rises again at age 11 and nearly 50% of 11 year olds have ticked "Plants". The remaining 50% of children who have not ticked the Plants box have an incomplete concept of

microscopic life.

(c) Children who ticked the Particles box

Over 50% of children at every age level ticked this box, showing that many children have the erroneous idea that particles are living. The results are similar for all the age bands except age 8. At age 8, the percentage is significantly higher than the percentages at all other age levels. (1% significance at age 11).

Probably many 7 year old children, and some older children too, will not have heard about particles inside a substance and they would find it difficult to decide whether the particles are living or not. A much lower percentage at age 7 ticked "particles" compared to the percentages for "animals" and "plants". At age 8, more children will have heard or read about particles, due to their increased acquisition of knowledge. In the Pilot Study, the two children who expressed the idea that particles are living were aged 73/4 and 8. They had learned something about particles, although their understanding was vague, and had developed the idea that these are living. Perhaps, as they get older, more children realise that this idea is false, but over 50% of children at age 11 are still retaining this erroneous idea.

At age 8, a significantly higher percentage of boys ticked the Particles box. This is the only difference between boys and girls in Question 4. This agrees with the result from the Pilot Study where the idea of particles being living was expressed by two boys and by no girls. More boys of 8 than girls will have an interest in the physical aspects of science and more of the boys will have read about particles or learned about them on television. The result is that more boys have the erroneous idea that particles are living.

At every age level except age 7, a higher percentage believe that particles are living compared to the percentage who ticked "Plants". So many children do not have a complete concept of microscopic life and they exclude microscopic plants from the living category. Further questioning of the children who ticked "Particles" would be necessary in order to find out their reasons for believing that particles are living. The movement of particles, which children will have heard about, is probably the main reason. It seems that some children have formed an erroneous idea which is based on some facts which they have encountered and which they do not fully understand.

Summary: Question 4

This question may not have provided genuine information on childrens' beliefs about particles and about microscopic life. Therefore the question should be repeated after having been planned more wisely. It should be worded more carefully and designed in a way which would be understood easily by children as young as 7. This would ensure that the question was yielding the correct information. A more detailed study, by itself, could also be carried out concerning childrens' ideas about microscopic things.

Quesion 5: Attributes of Living Things

(a) Attributes given by children (Table 5.14)

The words which children wrote in their responses to Question 5 were grouped together into nineteen categories. Eighteen of these are attributes of living things, many ofwhich pertain to animals, and one is the category "Plant". Included in the list are the seven attributes of all living things: Movement, Nutrition (Eating), Sensory System (Senses), Reproduction, Respiration (Breathing), Growth and Excretion. All of these appeared amongst the results, but it is clear that children use many other attibutes as well.

The results show the great variety of words which children used in their responses, although some categories included only one or two words. The nineteen categories were chosen as a result of childrens' responses and were not created independently of the results.

(b) Age 7 (Table 5.15)

A significantly higher percentage included the attribute "movement" compared to all other age levels. When the 7 year olds were imagining an animal, nearly all of them gave movement as an attribute because it is the most obvious one to them. Older children were imagining a mystery living thing and not all of them would think of movement as an attribute.

Eating and noise are also obvious, external attributes with which children of 7 and under will be familiar, mainly because of their pet animals. The attribute noise pertains to some living things and to many non-living things. If a child is thinking solely of a large animal, then noise is a genuine attribute and this explains why a significantly higher percentage of 7 year olds included it compared to all other age levels. The percentage at age 7 for Eating is significantly higher than the percentages at age 9 and age 10. Many children of 7 would think of eating when they were imagining an animal whereas the older children would

be thinking of a greater variety of attributes which pertain to a living thing.

At age 7 the percentage for Movement is very high compared to the percentages for other attributes, and the percentages for the living attributes of Reproduction, Breathing, Growing and Excretion are very low. It is clear that children of 7 do not think of these attributes when they are asked to explain why an animal is living.

The only child who gave Excretion as an attribute was aged 7. Perhaps more older children would have included it but were too embarrassed to do so. It seems that excretion is not at the forefront of childrens' minds when they are thinking of attributes. In their daily life they most likely connect it with eating and digestion and do not consider it to be a separate attribute.

No child aged 7 gave the attributes "tail", "four legs", "size" or "habitat". Since they were asked to imagine an animal, they would not be likely to ask questions which used these words. The percentages for Legs, Size and Habitat, are all significantly less than the percentages for these objects at other ages. However, defence was important to some children and a few included "fur" and "legs" The percentage for "fur" is significantly less than the percentage at ages 9 and 11. Two per cent included "heart", but none of them included "blood" or "cells". Perhaps they are more aware of the heart and its importance in maintaining life, due to hearing about heart transplants. Children of 7 will probably not know about cells in living animals.

(c) Ages 8 to 11 (Table 5.15)

The percentages for Movement are high at every age level which shows that this attribute is the most important of the seven living attributes in childrens' minds. The percentages for Eating and Senses are smaller, and for Senses there are no significant differences between the age levels. The percentages for the other four living attributes are all very small. Even at age 10 and 11, children do not think of these attributes when they are asked to describe a living thing.

At every age level, except age 7, a high percentage of children included attributes such as legs, fur, tail, size, defence and habitat. These attributes suggest that children were thinking mostly of large animals when they were imagining a living thing. Their concept of animal is a thing with legs, fur and a tail and of average size. This is not the correct, biological concept but it is a child's concept of an animal. Compared to the 7 year olds, older children have

included more detailed and sophisticated attributes, as well as the common attributes "movement" and "eating". Children of 10 and 11 do not seem to have a more developed concept of life than younger children. The older children do not give the living attributes more often than younger children.

(d) Ages 9 and 10

The percentages for Legs and Fur are significantly higher compared to the percentages at age 8 and age 11, and for Legs only, at age 10. Many children of 9 are using these attributes to describe a living thing. At age 10, the percentages for Size and Habitat are significantly higher than at age 11, and for Size only than at age 9. At age 10, many children will have read a lot about animal life and plant life, and they think of questions pertaining to size and habitats when they are describing a living thing. Children of 11 have not used these attributes as often as the 10 year olds.

Not one child of 9 included blood, heart or cells in their answer even although 2% at age 8 included blood. At age 9, most children are still not thinking of attributes which are not externally obvious, even although most children will know about these things. At age 10, a few children included heart and blood.

4% of children aged 9 and 3% of children aged 10 included words in the plant category. With increasing age children are more aware of plants as living things and their concept of life is not restricted to animals.

(e) Age 11

The percentages for both movement and breathing are significantly higher than the percentages for these attributes at ages 8, 9, and 10. This shows that more children of 11 compared to younger children have correctly included these two living attributes and their concept of life is more advanced than that of the younger children. The percentage at age 11 for eating is also significantly higher than the percentage at age 10; eating is another of the living attributes. At every age level the percentages for breathing are small, but more children of 11 compared to younger children are aware of the importance of this attribute. They will have become aware of it in their own lives and from reading about animals and their development. However, only 18% of 11 year olds included "breathing".

Small percentages of children included "blood", "heart" and "plant", and one child

included "cells". Although most children of 11 will know somethng about cells, plants or blood, most of them do not include these things when they are giving attributes of life; they obviously do not think of them when they think of attributes. At age 11, children may have more developed ideas and have acquired more knowledge than younger children, but many of them do not know the seven attributes of living things and do not include important attributes like reproduction, breathing, growth and excretion when they are asked to say why an object is living. Most children still include attributes which pertain to a large animal.

(f) Sex Differences

There are several significant differences between the percentage of boys and the percentage of girls at certain age levels as follows:-

Age	Attribute	Significantly higher
8	Movement	Girls
	Senses	Girls
	Fur	Girls
	Size	Girls
	Defence	Girls
9	Senses	Boys
	Four legs	Girls
10	Reproduction	Boys
	Tail	Boys
	Defence	Boys
	Habitat	Girls

(i) Age 8

A significantly higher percentage of girls have included the attributes movement and senses. At this age it seems that more girls compared to boys have thought of these attributes of life when they are describing a living thing. Since a higher percentage of girls also included "fur" and "size" the girls may have been imagining a small, furry animal and it would be easier for them to include attributes like movement and senses. More of the boys may be imagining larger animals, birds or insects and they have included a variety of other attributes in their answers.

The girls also have a significantly higher percentage for "defence" compared to the boys. Perhaps girls are more aware of the facets which make up defence because they are mostly more fearful and timid than the boys. Boys of 8 are not thinking as much about how fierce the living thing is or how frightening it could be.

(ii) Age 9

The result for Senses is completely opposite to the result at age 8, because at age 9 the percentage of boys is significantly higher. It is difficult to explain this result and it would be necessary to examine the childrens' answers in more detail, in order to find out which part of the sensory system each child was referring to. Then a more accurate conclusion could be made, and the results for age 8 and age 9 could be compared.

A significantly higher percentage of girls included the attribute "four legs". When a child included this attribute he or she would be referring specifically to a four legged animal and not to a bird or an insect or to any other living thing. More girls than boys at age 9 have asked if the living thing has four legs. By using this attribute they are distinguishing a four-legged animal from other animals and they are thinking of the living thing in more detail than children who have asked "how many legs has it". The percentages of children who included "four legs" are less than the percentages who included "legs" at every age level.

(iii) Age 10

The percentage of boys is significantly higher for reproduction. At this age more boys than girls hve thought of the reproduction of a living thing. It may be that many of the boys have asked the question, "Does it lay eggs," because they are interested in birds and birds' eggs at this age, and they have in this way been made aware of reproduction in living things.

A significantly higher percentage of boys have included "tail". This attribute could refer to a great variety of animals including birds and insects, and more boys than girls have thought of the tail as being part of a living thing. The percentages for "tail" were low at every age level.

The percentage of boys is also significantly higher for the attribute "defence". This is a reversal of the result at age 8 where more girls included it. At age 10 more boys compared to girls will be interested in how fierce a living thing is and how it protects itself from its enemies. Perhaps at this age the boys are more interested in war and defensive tactics and this carries over into their understanding of living things.

A significantly higher percentage of girls have included "habitat". The percentage is more than twice the percentage of boys. It may be that, at age 10, more girls compared to boys are interested in where animals and, to a lesser extent, insects and plants come from and in what conditions they live. Maybe girls of 10 read more about these topics and think about

them more than boys do. For both "habitat" and "defence" there are no differences between the sexes at age 11.

(g) The Seven Attributes of Living Things (Table 5.17)

The sets of percentages for each age level were compared in pairs using the Spearman Rank-Order Correlation (See Appendix, Page iv). This test showed that there is a significant relationship (at 1%) between the ranks, when ranked from 1 to 7, for all the pairs of age groups.

At age 11, both "breathing" and "growing" are ranked higher than at other age levels when the seven attributes are considered separately. This shows that children of 11 are more aware of the importance of these life attributes than younger children are. However, reproduction is ranked lower at age 11 than at other age levels. Although 11 year olds will probably have more knowledge about reproduction than younger children, it does not apparently follow that more children of 11 include "reproduction" as an attribute of life.

There is no change in the order of the seven attributes from age 7 up to age 10. "Movement" ranks first at every age level, then either 'eating' or 'senses' comes in second place. Children of all ages are aware of sensory systems in living things, although they would not denote them as such. They consider that organs like eyes, ears and a brain are important attributes of living things. Excretion comes last at every age level: most children do not think of it as a life attribute.

(h) The 19 Attributes (Table 5.18)

The sets of percentages for all of the nineteen attributes were also compared using the Spearman Rank-Order Correlation. This test showed that there is a significant relationship at least at the 5% level for all pairings except between age 7 & age 8, age 7 & age 9, age 7 & age 10. (See Appendix, Page v)

When the ranks for some of these age levels are examined, there are large differences for certain attributes. Legs, size, fur and habitat all rank high at age 11 but are ranked lowest at age 7 because the younger children were imagining one animal and because they use less sophisticated attributes. Noise ranks high at age 7, but it is ranked fairly low at age 11. It is

a simple attribute and pertains to non-living things as well. The 7 year olds probably thought of all the active things which an animal could do when they were thinking of attributes. Movement, eating and noise have the three highest ranks at age 7.

At age 11, there are some attributes which were not given by any child of 7, e.g., "plant", "blood" and "cells" although these are ranked very low. "Excretion" comes last at age 11, because no child of this age included it. Also "reproduction" is ranked much higher at age 7 than it is at age 11.

(i) Ranking of the Seven Life Attributes (Table 5.19)

When the seven attributes are ranked with all the other attributes from 1 to 19, it is clear that "movement", "eating" and "senses" rank highest at every age level. "Excretion" ranks very low at all ages except age 7. "Reproduction", "growing" and "breathing" rank fairly low, with the exception of "breathing" at age 7 and age 11.

In terms of the biological view of the attributes of living things, the 7 year olds have come closest to it because of their ranking of the seven attributes. Unlike the other age levels, at age 7 the seven life attributes have high or fairly high ranks. Perhaps this is because the 7 year olds were only thinking of one animal when they were giving attributes and therefore it was easier for them to include the correct life attributes. However, most of the other attributes which the older children included applied to animals as well.

Summary of Question 5

Movement is the most, or second-most, common attribute at all age levels. Eating and Senses also rank relatively high. Attributes of life - breathing, growing, reproduction and excretion - are ranked low compared to other attributes which were given. Attributes which pertain to animals are common, especially at ages 8 to 11. The category "plant" is ranked very low and no child of 8 included it. Most children seem to have a concept of "animal", but most do not have a concept of "plant".

There are similarities at every age level in the attributes which children include. After age 7, children include more sophisticated attributes e.g. habitat, due to an increase in acquired knowledge and a more developed understanding of living things.

(a) The Work-sheet 'Alive or Not Alive'

Animals

The results from the work-sheet which accompanied the Computer Game (Table 5.20) show that all of the children included 'rabbit' and 'spider' in the living category. This agrees with the previous results in both the Pilot Study and Question 1, where the majority of children included an animal e.g. Cow, as being living. In the Pilot Study insects were also classed as living without any doubts.

Apple

However, only three pairs of children included apple as living compared to nine pairs who said that it was non-living, and, in one case, the decision involved considerable discussion. In Questions 1 and 2 on the main work-sheet, only 32% of 11 year old pupils included 'fruits' as being living, and about 50% said that fruits were living at one time. So a large proportion of pupils aged 11 still do not have a concept of dormant life.

Flame/Battery

Flame was included in the living category by seven pairs as opposed to four pairs who correctly classed it as non-living. This shows, in agreement with the result for Question 1, that there are still some pupils aged 11 who believe that a flame is living. Most of the pairs classed battery as non-living: at age 11 most children understand that it is not living in a biological sense. Two pairs of pupils had some discussion about it, but both finally classed battery as non-living.

Crystals

There is a considerable difference between the responses which were given by the two groups, Crystals (1) and Crystals (2). In the first group of pupils, who had not seen the crystal garden nor completed the main work-sheet in the class-room, all of them classed crystals as being non-living.

In the second group, who had seen the crystal garden, five pairs classed crystals as being living and two pairs classed them as being non-living. So the sight of the crystal garden has influenced some pupils' thoughts and they conclude that crystals must be living. In the Pilot Study several children said that crystals are growing or are 'like plants' and therefore they must be living. It seems that children believe that crystals are living because they possess

some attributes of living things. Also the visual effect of an object is of importance in determining what a child thinks about the object and whether it is placed into the living or non-living category.

(b) Questions Asked by Children (Table 5.22)

The pairs of children had to offer the computer questions which would distinguish an object which was known to the computer from the new object which they wanted to teach the computer.

Animals

The questions which were asked for 'rabbit' were mostly concerned with obvious external features of animals, e.g. ears and tail, where rabbit was being compared with mouse or spider. Attributes of movement (does it hop?) and size were also included in two questions.

For 'spider' the most frequently asked question was concerned with the spider's eight legs, which most children have obviously learned about, and which they used to compare spider with a four-legged animal. Other questions were concerned with colour, having a tail, and spinning a web which is an activity peculiar to spiders.

When these questions are examined overall, the content of them bears some resemblance to the attributes which children, aged 8 to 11, included in their responses to Question 5. When comparing two animals, children use questions which are concerned with external appendages and movement. Similarly, when they think of a living thing, most children are thinking of an animal and they give attributes pertaining to animals, even at age 11. More specifically, they include obvious attributes like external appendages and 'movement'.

Apple

The questions which were asked by children who said that 'apple' is living are different from the questions of the 'non-living' group. The questions asked by the 'living' group are all concerned with plant life and they have a biological connotation, e.g. words such as 'fruit', 'seeds', 'grow' and 'tree' are used. Apple was being compared with animals which shows that some children can distinguish attributes of animals from those of plants.

By contrast, the questions of the 'non-living' group are more simple and are concerned mainly with eating and with external differences which could also apply to non-living objects. So the questions which children ask about an object may differ depending on whether they

think that the object is living or not. In the same way, the attributes which children give to an object differ depending on whether they think that it is living or not.

Flame

The questions which were asked by pairs of pupils in both the Living group and the Non-living group are very similar. The questions are mostly concerned with heat and light, where 'flame' was being compared with both living and non-living objects. The idea of heat or burning seems to be at the forefront of childrens' minds when they think of a flame, as the previous results have also shown.

The question, 'does it move', was asked by one pair who correctly classed flame as non-living. Therefore some children aged 11 are aware, though perhaps unconsciously, that movement does not necessarily indicate that an object is living. In both the Pilot Study and Question 1, several children said that a flame moves and therefore it is living.

Battery

Once more, the questions which were asked by pupils in both the Living and Non-living groups are very similar, but there is more variety in the questions of the latter. The questions are mostly concerned with a battery 'having power' and 'making things work' and it was being compared in many cases with 'crystals'. One question was about the shape of a battery compared to the shape of a stone.

Children use the same attributes whether they are describing a battery, e.g. in the Pilot Study and Question 1, or comparing it with other objects. It is a question of language whether children class battery as being living or not. If the phrase 'living battery' means in a child's mind that the object is living, then it is classed as living. Other children know that a battery is not living and has no living attributes, even although it may be called a 'living' or 'dead' battery.

Crystals

The questions which were asked by children in Crystals (2), who had seen the Crystal Garden, are different from those asked by children in Crystals (1). Children in group (2) asked questions which referred to the Crystal garden and they used words such as 'like thread', 'grow in water' 'move' and 'hard' when comparing crystals with either living or non-living objects. This agrees with results from the Pilot Study and Question 1, when children who said that crystals are living expressed the idea of crystals growing or moving. Also the questions of

children in Crystals (2), who said that crystals are non-living, do not include these living attributes.

In contrast, questions which were asked by children in Crystals (1), who all classed crystals as non-living, referred to dry crystals and contained words such as 'clear', 'shiny' and 'sparkle'. So the words which children use to describe objects depends on whether they have classed the object as being living or not. It can also be said that the description which they give leads them to make a conclusion about whether the object is living or not living.

Summary - Computer Game

The use of a Computer game was an additional method for gaining information in this project and it was included experimentally. Although the game constituted a small part of the project, it has yielded a fair amount of information. The results have agreed, in many cases, with the results from the main work-sheet and from the Pilot Study, and they have also supplemented these previous results.

However, the number of children who were involved was small and the results have not been tested for significant differences. If a large sample of children of different ages was involved, then a proper study could be carried out. A more detailed and lengthy study by itself could be carried out by using this game or by designing a more elaborate game. A Computer game seems to be a very useful method for gaining information from children about their own ideas and beliefs, and this small part of the project has shown that there is potential in this method.

Chapter 7

Conclusions

Introduction: Childrens' Alternative Frameworks

Many children in the age range 7 to 11 years have incorrect ideas about which objects are living and which are non-living. They have formed mini-theories to explain things which they have encountered in the natural world around them. These mini-theories can be called alternative frameworks because they differ from the accepted scientific theory.

For example, many children, the highest percentage being at age 7, think that crystals are living because they grow and because they look like plants. Older children are less likely to be deceived by appearance and a much smaller percentage of 11 year olds compared to 7 year olds think that crystals are living. 50% of children at ages 8, 9 and 10 still believe that the sun is living and the percentage at age 7 is higher. This is a simple, animistic idea which children form to explain the sun's movement and giving of light and heat. The attributes heat and movement suggest life to a child and they cause some children at every age level to think that a flame is living. An average of about 16% at every age level believe that a battery is living because it has power and can make things work. Although several children said that a battery could be called 'living' or 'dead', they stated that this is a different kind of life from that of a plant or animal. So language may influence children in their categorisation of an object. Several children, mostly aged 7 and under, believe that a clock is living because it goes or works.

Since erroneous beliefs and alternative frameworks have been found in substantial percentages of children in the age range 7 to 11 it is clear that some action must be taken accordingly. Firstly, teachers are probably unaware that these frameworks exist in many school children. This study aims to make Primary teachers and Secondary Biology teachers aware of the problem - that many children have these alternative frameworks which may hinder learning of the true facts and make understanding of concepts difficult. If frameworks exist in the area of the life concept, it is likely that they will also exist in other concepts which are encountered at Primary school. However, this study is only concerned with the life concept.

Teachers may have come across childrens' beliefs and have encountered their alternative frameworks during class discussion, answering of questions or in childrens' essay-writing.

They may have dismissed the ideas as ideas which children will "grow out of" and have largely ignored them, or they may have told the child simply that the idea is wrong. Or they may have corrected the child in some way but have no evidence to show that the child has abandoned an erroneous belief and has formed a correct concept.

Teachers need to be aware that the same frameworks can exist in children of 11 as exist in children of 7. For example, some children aged 11 still believe that the sun is living because it moves and gives light, and that crystals are living because they grow. These children have not changed their ideas and beliefs since the age of 7. Many children of 10 and 11 still do not class mould as being living. Substantial numbers of children aged 10 and 11 do not have a concept of dormant life and therefore do not class a potato or fruit as being living.

Most children said that a potato, fruit or seeds were not living unless they were part of a plant or were in the ground. A large percentage of children at age 11 included potato and fruits in the category "not living now but came from a living thing" and they matched these two objects to 'plant' in Question 3. The percentage of girls of 11 was higher than the percentage of boys, which shows that more girls than boys view these objects as products of a living thing. Children of 10 and 11 may have more developed ideas than younger children but the ideas may be wrong. They may have more sophisticated knowledge than children of 7 and 8, but they still have little understanding of dormant life.

Another erroneous idea, which is present in over 50% of children at all age levels, is the belief that the tiny particles inside substances are living. This is probably a misconception, since it is formed by children after they have read about these particles or heard about them from television. They have developed the idea that the particles are living probably because of their movement.

Development of the Life Concept

Since the life concept is a pre-requisite concept for learning more difficult ones in later years of education e.g. photosynthesis, digestion, then a thorough understanding of it is essential for further learning in Biology. If pupils enter Secondary school with a minimal understanding of the life concept and the attributes of living things, then they will have problems with learning in Biology. They should not begin a formal Biology course in S.1 until they have a proper understanding of the life concept and until teachers are certain that they have abandoned any erroneous beliefs and alternative frameworks.

The concept of life begins to develop at an early age. Nearly every child, down to age 5, was certain that an animal is living. Animals are the first living things, apart from human beings, with which children come in contact. They will make observations and build on these until a concept of "animal" is formed. Because they are most familiar with animals, it is easy for children to understand that animals are living things. Since the "life" of an animal is very similar to the "life" of a human, the majority of children, by age five, can say with certainty that animals are living.

Most children aged 8 up to 11 years included plants as being living. Children of 7 probably found it more difficult to imagine a plant which can have many different forms, and they will not have thought about plants as much as older children. Over 75% of children included a tree as being living. The fact that they have green leaves was given as the reason why plants and trees are living. The word "growing" was not used, but several children referred to plants as having need of soil or water in order to live.

Very small numbers of children included objects like stones, meat, bread, leather and sugar as being living. Most children at age 11 and many children at the other age levels were able to place meat in the correct category "not living now but came from a living thing" and to match meat to cow. Children are not so familiar with leather and its origin; there are many children aged 7 to 9 who do not know where leather comes from. The percentages of children who placed bread in the correct category were small. Perhaps many children think of it as coming from grain or flour which they would class as non-living, rather than from a plant. Most children are not as certain about placing sugar in the correct category and matching it to plant as they are about meat, although both are common foods. For all four objects a development in understanding with increase in age was apparent. Children of 10 and 11 will have learned more about objects and their origins than younger children and will also find it easier to select the correct objects and match them accordingly.

If children can find attributes of life for an object, whether it is living or non-living, then they will say that it is living. Various attributes cause children to think that crystals, the sun or a clock are living. As children become older and gain more experience of life, more of them realise that these objects are non-living, despite the fact that they appear to have some attributes of life. When children realise that an inanimate object can have attributes like movement, heat and "growth", then they abandon their alternative framework and they

understand that the object is not living. So there is, in some children, development in understanding of the life concept with increase in age. In some cases, children of 10 did not show an increase in understanding compared to children of 9 and 7. A more detailed study of 10 year olds would have to be carried out in order to discover the reasons for this discrepancy.

The attributes of life

Before beginning a formal Biology course at Secondary school, children should know the seven attributes of livng things - movement, nutrition (eating), senses, reproduction, respiration (breathing), growth and excretion. When asked to describe a living thing, the attribute which was included most often by children at every age level was movement, and the percentage at age 7 was higher than all the other percentages. "Eating" and "Senses" came second and third respectively, and at age 7 many children included "noise" as an attribute. In contrast, very small percentages of children included the attributes reproduction, breathing, growing and excretion, even at ages 10 and 11. Only 18% of 11 year olds included breathing but this was significantly more than at ages 8, 9 and 10. Large numbers of children aged 8 up to 11 included attributes which pertain to a large animal e.g. size, habitat, legs, fur, defence. These children used more detailed and sophisticated attributes than the 7 year olds. At ages 9, 10 and 11 only a few children included words which come into the category of "plant". The majority of children used attributes which refer to animals or insects and not to plants, even although they know that plants are living things. Most children used attributes which refer to a large, furry animal and did not use four of the seven attributes of living things

In S.1, pupils do learn about the attributes of living things as part of their Biology course, but this may not be sufficient. If most pupils of 11 do not give the seven attributes of life except "movement" and "eating", then it is expected that most S.1 pupils would give the same. Therefore they will view attributes such as breathing, growth and excretion with great surprise and may not readily take this new piece of learning into their minds. A thorough teaching of the facts about attributes is necessary in order to make sure that S.1 pupils understand these attributes and their importance in the description of all living things.

If this thorough teaching is not carried out, then many pupils will retain alternative frameworks and will still have them when they are learning Biology at 'O' Grade. Pupils will have difficulty understanding their studies and will resort to rote-learning in order to pass exams. Rote-learning is not meaningful and it is not retained. Several studies have found that

children have two compartments of learning - their own personal ideas co-existing with facts learned in school(36, 47, 55, 56). Thus many children may retain their wrong ideas and rote-learn the correct facts for exams or in order to please the teacher.

Exposure of Alternative Frameworks

Teachers in both Primary and Secondary school have to be aware that alternative frameworks are present in many children and it is helpful if teachers know the nature of childrens' ideas and beliefs. Teaching and learning are both made more meaningful in this way. So childrens' beliefs and ideas need to be exposed both in individual children and in a class as a whole.

In the area of the life concept the exposure of any alternative frameworks could be carried out at Primary School,before the first period of instruction is given about living things. Exposure could take the form of class discussion followed by a presentation of the facts about living things. When childrens' frameworks are exposed during discussion the teacher can point out the falseness of these and then present the correct facts. In some cases, each child or group of children could be interviewed by the teacher in order to find out whether alternative frameworks are still present. This method of instruction about living things could be carried out in children as young as age 7, and it could be continued in each Primary class in order to reinforce the correct ideas in childrens' minds.

Having exposed the alternative frameworks, it is then necessary to help children to see how false their beliefs are, so that they will want to abandon them. Until they see that their beliefs are erroneous, children will not abandon them but will retain them, since they represent the best way for them of viewing the world around them. However, if children see that their frameworks are false, then they will abandon them and believe the correct framework. They have to know and understand that this framework is valid for the piece of learning to which it applies. This can be brought about by careful explanation and reinforcement until a child holds to the correct theory.

When children enter Secondary school they could be tested on their knowledge of living things using Diagnostic tests,which are another method of exposing alternative frameworks. Ideally there should be liaison between Primary teachers and Secondary Biology teachers concerning the whole area of the life concept. By age 12 or 13, most children should have correct ideas about what is living and what is non-living and most of them should know the

seven attributes of living things.

Children are then ready to proceed further with instruction in Biology and will be ready to learn and understand the more difficult and abstract concepts like Photosynthesis, Digestion and Respiration. Having been prepared adequately by learning correct facts about living things, the pupils will then be able to understand these abstract concepts and will remember the facts concerning them. There will be less rote-learning in order to pass exams and learning will not be carried out simply to gain an exam pass. Further diagnostic testing could be carried out in SII and SIII in order to find out if there were any children who still had alternative frameworks in the area of the life concept. This would also show how many children had definitely grasped the correct frameworks and had abandoned their own erroneous ideas. Without an adequate understanding of the life concept, chidren have no foundation on which to place further learning and, as Ausubel said, "The most important factor influencing learning is what the learner already knows". (62)

Suggestions for Further Work

It would have been of interest to extend the present research study to include children in S.I and SII. Their beliefs about living things and the attributes of life which they included could have been examined and then compared with those of the Primary children. This information would show whether there were any differences between Primary childrens' ideas and those of children in S.I and S.II, and it would be helpful for Secondary Biology teachers to have such information.

A further piece of research, which would require more time, would be to carry out a long-term study of pupils, starting at age 9 or 10 and following the same group of pupils through to S.III and S.IV. This type of study would look at the development of ideas about living things in a sample of children as they increase in age, and it would have to be carried out over a number of years. An additional piece of research would be to find out the beliefs about living things which may be present in a sample of adults, and to compare these beliefs with the results for Primary and Secondary school-children. This study would find out whether there are alternative frameworks about living things amongst the adult population. Another related research study could examine when children learn about parts of the body and the wrong beliefs which they may have about the positions of organs in the body.

There has not been enough research carried out on Primary school-childrens' alternative

frameworks, whether to expose them or to find out how they develop and change with increasing age. There has been very little work done on children below age 8 or 9, which suggests that researchers do not realise the importance of studying young childrens' beliefs. Most studies of alternative frameworks are in the fields of Chemistry and Physics and there is a need for more studies on biological topics. The lack of these studies may be due to the fact that many people think that Biology is an easier subject than Chemistry or Physics. However, there are some very complicated and difficult concepts in Biology, such as Photosynthesis and D.N.A., and pupils need to have a good foundation of learning before they are presented with these concepts.

It would be useful to carry out a detailed study of childrens' beliefs about microscopic life, because children need to have a good foundation in this area as well before they continue with Biology in Secondary school. In Biology it is important that pupils have a concept of size of different organisms, both micro and macro organisms. Many Secondary pupils and University students do not have a correct concept of size in Biology and this causes confusion and the development of wrong ideas. This study has showed that many pupils, even at age 10 and 11, do not include microscopic animals and plants as being living. In addition, about 50% of children at every age level believe that the particles inside substances are living.

More studies of childrens' alternative frameworks, whether individually or as a class, could be carried out using games on a computer. In this study, the Computer game was used experimentally and it yielded a sizeable amount of useful information about childrens' ideas. The use of a computer game would be a new method for gaining information about childrens' natural ideas without having an interviewer or an adult interfering. Children would be more likely to tell the computer what they actually believe than they would tell an adult. Computer games could be designed to carry out a complete study of childrens' beliefs about living things or about many other topics, and it is hoped that these games will be made use of by research workers in the future.

References

1. Driver, R. (1981). Pupils' Alternative Frameworks in Science. Eur. J. Sci. Educ., 3, 1, p.p. 93 - 101.
2. Erickson, G.L. (1979) Childrens' Conceptions of heat and temperature. Science Education, 63 (2), p.p. 221 - 230.
3. Driver, R. & Easley, J. (1978) Pupils and Paradigms: a Review of Literature Related to Concept Development in Adolescent Science Students. Studies in Science Education, 5, p.p. 61 - 84.
4. Arnold, B. & Simpson, M. (1980). An Investigation of the Development of the Concept Photosynthesis to S.C.E. 'O' Grade. (Research Report) Aberdeen College of Education Publication.
5. Champagne, A.B., Gunstone, R.F. & Klopfer, L.E. (1983). Naive Knowledge and Science Learning. Res. in Sci. and Technol. Educ., 1, No. 2, p.p. 173 - 183.
6. Osborne, R.J., Bell, B.F., & Gilbert, J.K. (1983). Science teaching and childrens' views of the world. Eur. J. Sci. Educ., 5 1. p.p. 1 - 14.
7. Claxton, A. (1982). School Science: Falling on Stony Ground or Choked by Thorns? In C. Sutton, "Investigating Childrens' Existing Ideas about Science". University of Leicester, School of Education Publication.
8. Viennot, L. (1979). Spontaneous reasoning in elementary dynamics. Eur. J. Sci. Educ., 1, 2, p.p. 205 - 221.
9. Nussbaum, J. (1981) Towards the Diagnosis by Science Teachers of Pupils' Misconceptions: an Exercise with Student Teachers. Eur. J. Sci. Educ. 3, 2, p.p. 159 - 169.
10. West, L.H. T. (1982) "The researchers and their work", and "What is the Value of these Studies" In C. Sutton & L. West, eds.,"Investigating Childrens' Existing Ideas about Science". University of Leicester, School of Education Publication.
11. Driver, R. (1983). "The Pupil as Scientist". Open University Press.
12. Harlen, W. (1983). Basic concepts and the primary/secondary science interface. Eur. J. Sci. Educ. 5, 1, p.p. 25 - 34.
13. Sére, M-G. (1982). A study of some frameworks used by pupils aged 11 to 13 years in the interpretation of air pressure. Eur. J. Sci. Educ., 4, 3, p.p. 299 - 309
14. Deadman, J.A. & Kelly, P.J. (1978). What do Secondary School Boys Understand about Evolution and Heredity before they are taught the topic? J. of Biol. Educ., 12 1, p.p. 7 - 15.
15. Solomon, J. (1982) How children learn about energy or Does the first law come first? School Science Review, 63, 224, p.p. 415 - 422.
16. Halldén, O. (1983) Teachers' questions and pupils' problems: a commentary. Eur. J. Sci. Educ., 5, 3, p.p. 333 - 336.
17. Kargbo, D.B., Hobbs, E.D. & Erickson, G.L. (1980) Childrens' beliefs about inherited characteristics. J. of Biol.Educ., 14 (2), p.p. 137 - 146.

18. Hewson, P.W. (1981). A Conceptual Approach to Learning Science. Eur. J. Sci. Educ.,3, 4, p.p. 383 - 396.

19. Simpson, M & Arnold, B. (1984) "Diagnosis In Action". Occasional Paper No. 1, Aberdeen College of Education.

20. Gilbert, J.K. & Osborne, R.J. (1980a) "I Understand but I don't get it": some problems of learning science. School Science Review, 61, 217, p.p. 664 - 674.

21. Solomon, J. (1983a) Learning about energy: how pupils think in two domains. Eur. J. Sci. Educ., 5, 1, p.p. 49 - 59.

22. Za' Rour, G.I. (1975) Science misconceptions among certain groups of students in Lebanon. J. of Research in Science Teaching, 12, p.p. 385 - 392.

23. Ward, A. (1983a) Infants can study air science. School Science Review, 64, 229, p.p. 656 - 60.

24. Head, J. (1982) What can psychology contribute to science education? School Science Review, 63, 225, p.p. 631 - 642.

25. Solomon, J. (1980). "Teaching Children in the Laboratory" Croom Helm, London.

26. Strike, K.A. & Posner, G.J. (1982). Conceptual change and science teaching. Eur. J. Sci. Educ., 4, 3, p.p. 231 - 240.

27. Karmiloff-Smith, A. & Inhelder, B. (1974). If you want to get ahead, get a theory. Cognition, 3 p.p. 195 - 212.

28. Donaldson, M. (1978) "Childrens' Minds". Fontana/Collins.

29. Driver, R. & Erickson, G.L. (1983). Theories In Action: some theoretical and empirical issues in the study of students' conceptual frameworks in science. Studies in Sci. Educ., (10), p.p. 1 - 36.

30. Watts, D.M. (1983). A study of childrens' alternative frameworks of the concept of force. Eur. J. Sci. Educ., 5, 2, p.p. 217 - 230.

31. Pope, M.L. & Gilbert, J.K. (1983). Explanation and metaphor: some empirical questions in science education. Eur. J. Sci. Educ., 5, 3, p.p. 249 - 261.

32. Green, B., McCloskey. M & Caramazza, A. (1980). Curvilinear motion in the absence of external forces: naive beliefs about the motion of objects. Science, 210, p.p. 1139 - 1141.

33. Andersson, B. & Karrqvist, C. (1983). How Swedish pupils, aged 12 - 15 years, understand light and its properties. Eur. J. Sci. Educ., 5, 4, p.p. 387 - 402.

34. Lovell, K. (1961) "The Growth of Basic Mathematical and Scientific Concepts in Children". University of London Press, Ltd.

35. Nussbaum, J. & Novak, J.D. (1976). An assessment of childrens' concepts of the earth utilising structured interviews. Science Education, 60 (4), p.p. 535 - 550.

36. Driver, R. & Erickson, G.L. (1982) "The Study of Conceptual Frameworks: a meander in the field". In C. Sutton & L. West, eds., "Investigating Childrens' Existing Ideas about Science". University of Leicester, School of Education Publication.

37. Posner, G.J., Strike, K.A., Hewson, P.W. & Gertzog, W.A. (1982) Accommodation of a scientific conception: towards a theory of conceptual change. Science Education, 66 (2), p.p. 211 - 227.

38. Arnold, B. & Simpson, M. (1981). Diagnostic testing for pupil difficulties in osmosis: a teacher's handbook. Aberdeen College of Education Publication.

39. Arnold, B. & Simpson, M. (1982). Concept development and Diagnostic testing - Osmosis in 'O' Grade Biology. Aberdeen College of Education Publication.

40. Sutton, C. (1982). The Origin of Pupils' Ideas. In C. Sutton & L. West eds., "Investigating Childrens' Existing Ideas about Science". University of Leicester, School of Education Publication.

41. The Bullock Report: "A Language for Life". (1975) H.M.S.O.

42. Driver, R. (1973) The representation of conceptual frameworks in young adolescent science students. Ph.D thesis, Universtiy of Illinois, Urbana, Illinois.

43. Bell, B.F. (1981a) When is an animal not an animal? J. of Biol. Educ., 15, 3, p.p. 213-218.

44. Sutton, C. (1980b) Science, language and meaning. School Science Review, 62, 218, p.p. 47 - 56.

45. Bernstein, B. (1958) Some Sociological determinants of perception: An enquiry into subcultural differences. Brit. J. of Sociol. 9 p.p. 151-74.

46. Ross, K.A. & Sutton, C. (1982) Concept profiles and the cultural context. Eur. J. Sci. Educ., 4; 3, p.p. 311 - 323.

47. Solomon, J. (1983b) Messy, contradictory and obstinately persistent: a study of children's out-of-school ideas about energy. School Science Review, 66, 231, p.p. 225 - 230.

48. Johnstone, A.H. & Cassels J.R.T. (1978) What's in a word? New Scientist, 18 May,p.p. 432 - 4.

49. Summers, M.K. (1983) Teaching heat - an analysis of misconceptions, School Science Review 64, 229, p.p. 670 - 676.

50. Osborne, R.J. (1981) Science Education: Where do we start? Keynote Lecture to the Conference of the Australian Science Teachers' Association, Melbourne, August, 1981.

51. Kuethe, L.J. (1963) Science concepts: A study of sophisticated errors. Science Education, 47, p.p. 361 - 364.

52. Mitchell, A. & Kellington, S. (1982) Learning difficulties associated with the particulate theory of matter in the Scottish Integrated Science Course. Eur. J. Sci. Educ., 4, 4, p.p. 429 - 440.

53. Lucas, A.M. (1971) The teaching of adaptation. J. of Biol. Educ., 5, (2) p.p. 86 - 90.

54. Brumby, M. (1979) Problems in Learning the Concept of Natural Selection. J. of Biol. Educ. 13 (2) p.p. 119 - 122.

55. Simpson, M. & Arnold, B. (1982b) The inappropriate use of subsumers in biology learning. Eur. J. Sci. Educ., 4, 2, p.p. 173 - 182.

56. Engel, E. & Driver, R. (1981) "Investigating Children's Ideas about Pressure". In "Proceedings of the International Workshop on Problems Concerning Students' Representation of Physics and Chemistry Knowledge". Ludwigsburg, 1981.

57. Nussbaum, J. (1979) Children's conceptions of the Earth as a cosmic body: a cross-age study. Science Education, 63, 1, p.p. 83 - 93.

58. Tamir, P., Galchoppin, R. & Nussinovitz, R. (1981). How do Intermediate and Junior High school students conceptualise living and non-living. J. of Research in Science Teaching, 18, (3) p.p. 241 - 248.

59. Brumby, M. (1982) Students' perceptions of the concept of life. Science Education, 66, p.p. 613 - 622.

60. Gilbert, J.K. & Watts, D.M. (1983) Concepts, Misconceptions and Alternative Conceptions: Changing Perspectives in Science Education. Studies in Science Education, 10, p.p. 61 - 98.

61. Rowell, J.A. & Dawson, C.J. (1983) Laboratory counter-examples and the growth of understanding in science. Eur. J. Sci. Educ., 5, 2, p.p. 203 - 215.

62. Ausubel, D.P. (1968) "Educational Psychology: a Cognitive View". Holt, Rinehart.

63. Hewson, P.W. (1982) A Case Study of Conceptual Change in Special Relativity: the Influence of Prior Knowledge in Learning. Eur. J. Sci. Educ., 4, 1, p.p. 61 - 77.

64. Smith, H. (1975) "Writing in Science". Schools Council and London University Institute of Education Joint Project, 1975.

65. Osborne, R.J. & Gilbert, J.K. (1980a). A Method for Investigating Concept Understanding in Science. Eur. J. Sci. Educ., 2, 3, p.p. 311 - 321.

66. Richards, J. (1982) "How Language contributes to formation of concepts". In "Pupils' Learning Problems in Certificate Biology". Proceedings of National Course, 1981. Aberdeen College of Education Biology Dept. Publication.

67. Petrie, H.G. (1979) Metaphor and Learning. In "Metaphor and Thought," ed. A. Ortony. p.p. 438-61. Cambridge University Press, Cambridge.

68. Nussbaum, J. & Novick, S. (1981). Brainstorming in the class-room to invent a model: a case study. School Science Review, 62, p.p. 771 - 778.

69. Simpson, M. & Arnold, B. (1982a) Availability of pre-requisite concepts for learning Biology at certificate level. J. of Biol. Educ., 16, (1), p.p. 65 - 72.

70. Simpson, M. & Arnold, B. (1983). Diagnostic Tests and Criterion - Referenced Assessments: their Contribution to the Resolution of Pupil Learning Difficulties. Programmed Learning and Educational Technology, 20, (1), p.p. 36 - 41.

71. Sutton, C. (1980a) The Learner's Prior Knowledge: a Critical Review of Techniques for Probing its Organisation. Eur. J. Sci. Educ., 2, 2, p.p. 107 - 120.

72. Ward, A. (1980) Questions of primary science: important questions which have been asked by teachers, with some practical answers. The School Science Review, 61, 217, p.p. 639 - 647.

73. Cosgrove, M., Osborne, R. & Tasker, R. (n.p.) Toward generative learning. Working Paper No. 205, Science Education Research Unit, University of Waikato.

74. Klausmeier, J.H., Ghatala, E.S. & Frayer, D.A. (1974) "Conceptual Learning and Development - a Cognitive View". Academic Press: New York.

75. Novak, J.D. (1978) An Alternative to Piagetian Psychology for Science and Mathematics Education, Studies in Science Education, 5, p.p. 1 - 30.

76. Schaeffer, G. (1979) Concept formation in biology: the concept 'growth'. Eur. J. Sci. Educ., 1, 1, p.p. 87 - 101.

77. Shayer, M. (1974) Conceptual demands in the Nuffield 'O' Level Biology course. The School Science Review, 56, (195), p.p. 381 - 388.

78. Okeke, E.A.C. & Wood-Robinson, C. (1980). A Study of Nigerian pupils' understanding of selected biological concepts. J. of Biol. Educ., 14, 4, p.p. 329 - 338.

79. Gagné, R.M. (1970). "The Conditions of Learning", (2nd edition). Holt, Rinehart & Winston.

80. Herron, J.D., Cantu, L.L., Ward, R. & Svinvisan, V. (1977). Problems associated with concept analysis. Science Education, 61, p.p. 185 - 199.

81. Renner, J.W. & Grant, R.M. (1978). Can students grasp physics concepts? The Science Teacher, 45, 7, p.p. 30 - 33.

82. Shayer, M. (1978) Nuffield Combined Science: do the pupils understand it? The School Science Review, 60, 211, p.p. 210 - 223.

83. Rae, G. (1982). "Gagné's Backward Analysis". In "Pupils' Learning Problems in Certificate Biology". Proceedings of National Course, 1981. Aberdeen College of Education Biology Dept. Publication.

84. Kempa, R.F. & Hodgson, G.L. (1976). Levels of concept acquisition and concept maturation in students of chemistry. Brit. J. of Educ. Psychol., 46, p.p. 253 - 60.

85. Aiello-Nicosia, M.L. & Sperandeo-Mineo, R.M. (1982). An experimental study of the relationship between formal thinking and physics achievement. Eur. J. Sci. Educ., 4, 2, p.p. 203 - 211.

86. Driver, R. (1978) When is a Stage not a Stage? Educational Research, 21, 1, p.p. 54 - 61.

87. Ryman, D. (1974) Children's understanding of the classification of living organisms. J. of Biol. Educ., 8, (3), p.p. 140 - 144.

88. Arnold, B. (1982) "Interference". In "Pupils' Learning Problems in Certificate Biology". Aberdeen College of Education Biology Dept. Publication. Proc. of National Course, 1981.

89. Sully, J. (1896). "Studies of Childhood". Longmans, Green & Co., London.

90. Piaget, J. (1929) "The Child's Conception of the World". Paladin, 1973.

91. Looft, W.R. & Bartz, W.H. (1969). Animism revived. Psychological Bulletin, 71, 1 - 19.

92. King, W.H. (1961). Symposium: Studies of childrens' scientific concepts and interests. Brit. J. of Educ. Psychol., 31, p.p. 1 - 20.

93. Bell, B.F. (1981b). Animal, plant and living-notes for teachers. Working Paper No. 30, Learning in Science Project, SERU, University of Waikato, Hamilton, New Zealand.

94. Looft, W.R. (1974). Animistic thought in children: Understanding of living across associate attributes. J. of Genetic Psychol., 127, p.p. 235 - 240.

95. Smeets, P.M. (1974) The influence of MA and CA on the attribution of life and life traits to animate and inanimate objects. J. of Genetic Psychol., 124, p.p. 17 - 27.

96. Brumby, M. (1981) Learning, understanding and 'thinking about' the concept of life. Australian Science Teachers' Journal, 27 (3), p.p. 21 - 25.

97. Osborne, R.J., Freyberg, P., Tasker, R. & Stead, K. (1981) Description, Analysis and Action: Three Phases of a Research Project. Res. in Sci. Educ., 11, p.p. 52 - 58.

98. Ward, A. (1982). Guidelines for later primary science education (ages 11 - 12): concepts and lesson contents. The School Science Review, 64, 226, p.p. 31 - 37.

99. Harlen, W. (1978) Does content matter in Primary Science. The School Science Review, 59, 209, p.p. 614 - 25.

100. Hadden, R.A. & Johnstone, A.H. (1982). Primary school pupils' attitudes to science: the years of formation. Eur. J. Sci. Educ., 4, 4, p.p. 397 - 407.

101. Acuna, J.E. (1983). The influence of acculturation on cognitive development. Eur. J. Sci. Educ., 5, 4, p.p. 415 - 428.

102. Egan, K. (1972) Structural communication - a New Contribution to Pedagogy. Programmed Learning and Educational Technology, 1972, 63 - 78.

103. Tuckman, B.W. (1972) "Conducting Educational Research". New York, Harcourt Brace Javanovich, 1972.

1. Test for Significant Differences

The results for Questions 1 - 5 on the work-sheet "Living or Not Living", were tested for significant differences using a graph (Appendix, Page ii) designed by Dr. N. Kellett. Percentages were tested for significance at 5% and 1% levels.

To compare percentages at one age level with percentages at another age level.

N_1 is the sample size at one age level

N_2 is the sample size at the other age level

e.g. Age 7 and Age 9,

Let $N_1 = 44$, $N_2 = 130$.

then $\frac{N_1}{N_2} = \frac{44}{130} = 0.34$

This is a value on the X- axis.

From graph, 0.34 corresponds to 113.6 on the Y-axis.

i.e. $\Delta = 113.6$ for 5% significance.

$$\frac{\Delta}{\sqrt{N_1}} = \frac{113.6}{\sqrt{44}} = \frac{113.6}{6.63} \simeq 17\%$$

If any result in first sample (Age 7) differs from any result in second sample (Age 9) by 17% or more, then the difference is significant at the 5% level.

For 1% level,

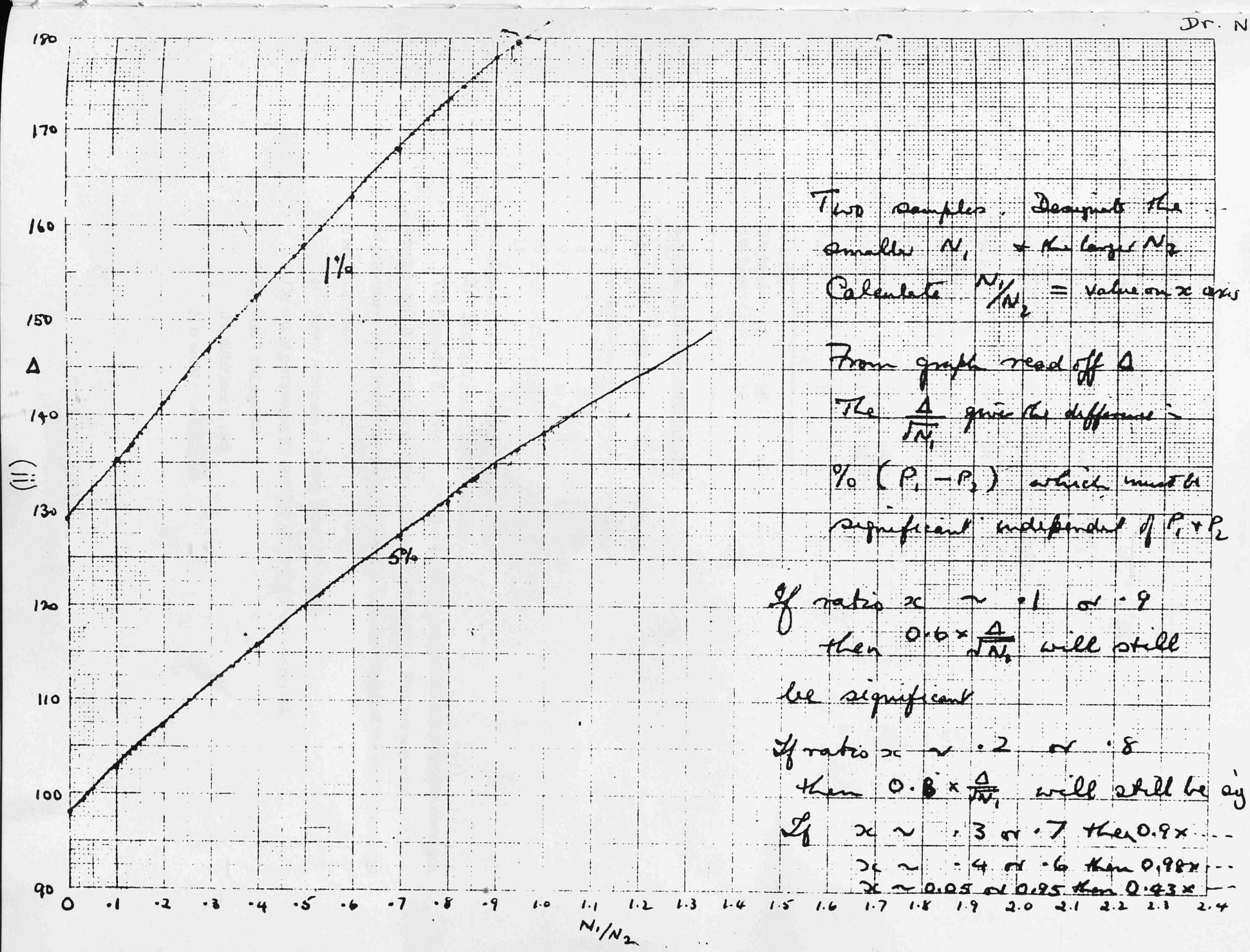
$$\Delta = 149.4$$

$$\frac{\Delta}{\sqrt{N_1}} = \frac{149.4}{\sqrt{44}} = \frac{149.4}{6.63} = 22.53\% \simeq 23\%$$

This is the percentage which is required for significance at 1% level.

This test makes no assumption about samples being normally distributed.

Dr. N. Kellett



Two samples. Designate the smaller N_1 & the larger N_2

Calculate N_1/N_2 = value on x axis

From graph read off Δ

The $\frac{\Delta}{\sqrt{N_1}}$ gives the difference in % $(P_1 - P_2)$ which must be significant independent of P_1 & P_2

If ratio $x \sim .1$ or $.9$ then $0.6 \times \frac{\Delta}{\sqrt{N_1}}$ will still be significant

If ratio $x \sim .2$ or $.8$ then $0.8 \times \frac{\Delta}{\sqrt{N_1}}$ will still be sig

If $x \sim .3$ or $.7$ then $0.9 \times$ ...

$x \sim .4$ or $.6$ then $0.98 \times$ ...

$x \sim 0.05$ or 0.95 then $0.43 \times$ ...

Percentages which are required for Significant Difference

Age 7	Comparison with Age			
N = 44	8	9	10	11
5% level	17	17	17	15
1% level	23	23	23	20

Age 8	9	10	11
N = 112			
5% level	13	13	10
1% level	17	17	13

Age 9	10	11
N = 130		
5% level	13	10
1% level	17	13

Age 10	11
N = 111	
5% level	10
1% level	13

Comparison Between Boys and Girls

Age	5% level	1% level
7	27	36
8	8	10
9	14	18
10	8	10
11	17	22

2. Spearman Rank-Order Correlation

The Spearman Rank-Order Correlation is used to compare two sets of ranks to determine whether there is a significant relationship between the two sets. This test was used on the sets of percentages which formed the results for Question 5, i.e. percentages of children who included a certain attribute.

a) Seven Attributes of Living Things (Table 5.7)

The sets of percentages for each pair of age levels were compared.

e.g. Age 7 and Age 11

d is difference in rank

N is number of attributes

Attribute	Age 7 Rank	Age 11 Rand	d	d^2
Movement	1	1	0	0
Eating	2	2	0	0
Senses	3	3	0	0
Reproduction	4	6	-2	4
Breathing	5	4	1	1
Growing	6	5	1	1
Excretion	7	7	0	0

$\underline{6}$

$\Sigma d^2 = 6$

$6\Sigma d^2 = 36$

$N = 7$

$N^3 - N = 336$

$$r_s = 1 - \frac{6\Sigma d^2}{N^3 - N}$$

$$= 1 - \frac{36}{336}$$

$$= 1 - 0.107$$

$$= 0.9$$

From Table VI, Appendix B of Tuckman (103) a rank-order correlation, r_s, of 0.9, or more shows a highly significant relationship between the rank orders. So the relationship between all of the sets is significant.

Significant Relationships

Ages	r_s	Significance
7 and 8	1.0	Significant
7 and 9	1.0	Significant
7 and 10	1.0	Significant
7 and 11	0.9	Significant
8 and 9	1.0	Significant
8 and 10	1.0	Significant
8 and 11	0.9	Significant
9 and 10	1.0	Significant
9 and 11	0.9	Significant
10 and 11	0.9	Significant

(b) Nineteen Attributes (Table 58)

e.g. Age 8 and Age 11

Attribute	Age 8 Rank	Age 11 Rank	d	d^2
Movement	1	1	0	0
Size	2	5	-3	9
Legs	3	3	0	0
Eating	4	2	2	4
Habitat	5	4	1	1
Senses	6	6	0	0
Defence	7	9	-2	4
Fur	8	7	1	1
Four legs	9	11.5	-2.5	6.25
Tail	10	14	-4	16
Reproduction	11	16	-5	25
Noise	12	10	2	4
Breathing	13	8	5	25
Blood	14	17	-3	9
Growing	15	14	1	1
Heart	17.5	14	3.5	12.25
Excretion	17.5	19	-1.5	2.25
Cells	17.5	18	-0.5	0.25
Plant	17.5	11.5	6.0	36
			$\Sigma d^2 = 156$	
			$6\Sigma d^2 = 936$	

$$r_s = 1 - \frac{936}{6840}$$

$$= 1 - 0.1368$$

$$r_s = 0.9$$

From Table VI, Appendix B of Tuckman (103) a rank-order correlation, r_s, of 0.6 or greater shows a highly significant relationship at the 1% level. r_s values between 0.4 and 0.6 show a strong relationship at the 5% level.

Nineteen Attributes: Significant Relationships

Between ages	r_s	Significance
7 and 8	0.3	Not significant
7 and 9	0.3	Not significant
7 and 10	0.2	Not significant
7 and 11	0.4	Significant (5% level)
8 and 9	1.0	Significant 1% "
8 and 10	1.0	Significant " "
8 and 11	0.9	Significant " "
9 and 10	1.0	Significant " "
9 and 11	0.9	Significant " "
10 and 11	0.9	Significant " "