CHILDREN'S BELIEFS
ABOUT
INHERITED CHARACTERISTICS

by

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ABSTRACT

Thirty two children (6 to 13 years) of average ability from three schools in Vancouver were interviewed about their beliefs regarding the phenomenon of inheritance. The study was purely exploratory. No hypothesis was tested. The subjects were exposed to five tasks, comprising twelve pictures, one live plant specimen and twenty questions. The first three tasks were designed to find out whether the subjects could differentiate between environmentally induced deformities and inherited traits in living organisms. The last two tasks were designed to find out whether the subjects invoke probability thinking in predicting the outcome of an offspring's inherited traits or not. The data collected was analyzed using tabular techniques:

(a) Frequency distribution table.

(b) Question-Response table.

The results indicate that a large proportion of the subjects from the various age groups had difficulties differentiating between environmental deformities and inherited traits. Since the difficulties and the successes with the three tasks investigating the problem were found in all the age groups, it was suggested that possibly the acquisition of this concept is not dependent on age but is rather a function of the subject's experiences. On the other hand, the development of the thinking related to the making of probabilistic predictions was believed to be developmental. Younger subjects (6 to 9 years) were rigid and predicted with certainty; whereas the older subjects (10 to 13 years) made very imprecise and tentative predictions about the outcome of the offspring.

This finding and others which are reported in this study about children's thinking regarding the phenomenon of inheritance, should help the curriculum developer and the classroom teacher in deciding how best appropriate learning opportunities could be provided for children (average ability) of the age groups that were studied.

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Chapter 1

INTRODUCTION

Scope of Problem and Aim of the Study.

This study was directed at identifying what beliefs that children of age 6 to 13 years possess regarding the phenomenon of inheritance. The study did not attempt to test any hypothesis. It was purely an exploratory investigation in which a moderately standardized form of the Clinical Interview Method was adopted to collect the data. The investigator had no preconceptions about the kinds of beliefs the children may have. However, it was his general assumption that all people regardless of whether they had formal schooling or not have intuitive notions about the phenotypic variations in height, size, ugliness, disease etc. that are exhibited by the various living organisms around them. The foregoing assumption arises from the fact that people encounter and recognize situations related to inborn characteristics in living organisms every day of their life. On account of this interaction one gradually builds up notions about the phenomenon of inheritance. An understanding of Mendel's theory of genetics as formally taught in school is not required in order to be able to develop these beliefs. It was therefore not surprising that the children who were studied were found to have formed their own ideas already about how the process of inheritance takes place. In this connection, some general problems which research psychology faces are:

- (1) developing a comprehensive picture of the beliefs children possess regarding heredity

- (2) recognizing the strengths and weaknesses of children in relation to the acquisition of the concepts of inheritance
- (3) recognizing difficulty levels of the subject matter of heredity for various age levels

The present study did not attempt to cover all of these problems. The aim was to identify what beliefs average ability children of age 6 to 13 years have about the phenomenon of inheritance. Specifically the study was addressed to finding out whether or not:

- (1) children of 6 to 13 years can distinguish between environmentally induced features and hereditary ones
- (2) children of age 6 to 13 years invoke probabilistic patterns of thinking in predicting the outcome of the offspring on the basis of the information given on the phenotypic traits exhibited by the parent(s).

The concentration of this study on these two problem areas came about because the investigator regards the appropriate development of these two thinking abilities (distinguishing between environmental features and hereditary traits, and probabilistic thinking in predicting offspring outcome) as very important prerequisites to a successful study of the subject of Genetics in school. The investigator is of the opinion that only when children's present beliefs are identified can teaching and learning strategies which are in tune with the children's difficulties be developed and implemented with success. The educational strategy advocated therefore is one which is based on the principle of understanding the nature of the learner--the child--on the basis of which meaningful teaching and learning strategies can be built.

Method for Collecting Data.

In this study a moderately standardized version of the Clinical Interview Method was adopted to collect data from the 32 subjects who participated. These subjects were students of average ability from grades 1 to 8 in three Vancouver schools. Each subject was interviewed for about 30 to 40 minutes in a quiet room provided by each of the schools. These interviews were audiotaped. In the course of the interview each subject was exposed to 20 questions pertaining to the subject of inheritance. The 20 questions were developed from 12 coloured pictures and one live specimen. The questions were accompanied by probings for clarification where this was deemed necessary.

Earlier Efforts.

A variety of educational researchers have done work to understand the nature of children's explorations, the cosmology developed in the process and the implications of these for the teaching-learning situation. Documented in the literature are efforts of great scientists such as Freud, Montessori, Herbert, Froebel, Dewey, to name a few who have aided in illuminating our understanding of children and the whole process of learning. Among contemporary scientists we owe our greatest debt to Jean Piaget for giving us the rudimentary framework upon which to build a better understanding of the nature of children and the process of intellectual growth.

Piaget in all of his research with children utilized the Clinical Interview Method. The Clinical Interview Method requires the investigator to engage in a free but constructive conversation with the subject on the topic in question, listen carefully to the responses of the subject and at the same time watch for reactions which may lead to further clues.

On the basis of the analysis of his findings about children using this method, Piaget identified four stages in the conceptual growth of children viz:-

(a) sensori-motor stage	0 - 2 years
(b) pre-operational stage	2 - 7 years
(c) concrete operational stage	7 - 12 years
(d) formal stage	12 - onwards (Chittenden 1970).

Within the frame work of these stages which run with corresponding ages one is expected to move from one stage to another with corresponding improvement in performance. Precisely this can be stated as follows:-

- (a) cognitive growth proceeds through certain stages
- (b) these stages occur in the same order for all individuals
- (c) each stage is characterized by the ability to perform certain functions and the inability to perform others (Kolodiy 1977).

Kolodiy further states that the "ontogenic development of structures can be thought of as a process of approximation to a kind of equilibrium, an end state never completely achieved." So the individual is found oscillating constantly between states of mental disequilibrium and equilibrium. Thus this quest to reach an idealized state of static mental balance urges one to go on learning all through life.

Implications.

If the above claim is true the quest for understanding of variation and inherited characteristics should run through all children with varying degrees of understanding. One wonders why the study of genetics as would be appropriate for the specific ages is not begun at an earlier grade in school. (In British Columbia schools it is not begun until grade 10.) The results of the present study, which was directed at identifying and

understanding children's patterns of beliefs in relation to inheritance, may provide some sense of direction to both teachers and curriculum developers with regards to the study of the subject of genetics in school.

Background and Reasons for the Study.

Any scientific observation of living organisms suggests similarities as well as differences among individuals comprising the families of these organisms - be they plants, animals or man. Though some of these traits are influenced by environmental conditions, the basic biological pattern is set by heredity. Thus some genes (the carriers of inherited material) respond differentially to a wide range of environmental conditions while others are more precise and restricted. It is this basic notion of inheritance that lead to the conscious effort of ancient people towards improving their plants and animal stock. According to Gardner (1968) even though ancient people did not understand the scientific mechanism of inheritance they achieved practical accomplishment with their intuitive notions of the phenomenon. For example Gardner (1968) reports of tablets of stone prepared by Babylonians 6000 years ago showing pedigrees of several successive generations of horses; artificial cross pollination of date palms; selective improvement of varieties of rice by Chinese farmers. During those times no success was achieved in explaining the underlying principles of inheritance. This was achieved only when Gregor Mendel (1865) came into the picture with his report on inherited characters of pea plants. His work was neglected though, until sixteen years after his death (Moon et al. 1947).

Earlier investigators were unsuccessful in unravelling the basic principles of inheritance because their explanations of the phenomena

were reported to be vague, unscientific or superstitious and thus contained serious flaws (Gardner 1968). Stories of unusual hybrids or crosses between organisms were reported. Great philosophers such as Aristotle, Hippocrates, Pliny 79-23 BC, Gesner 1516-1565 (Gardner 1968) reported inheritance tales of the giraffe being a result of a hybrid between the camel and the leopard; the ostrich as a product of the mating of the camel and the sparrow; banana trees were believed to arise from a cross between acacia and palm trees. Thus in man's effort to understand the problem of inheritance, fantastic explanations have evolved. It is strangely true that these tales have persisted among some peoples and are perpetuated per se. In other instances variations of them are often taught to children by parents in their effort to explain inheritance which their children are often eager to know about. These wrong notions take hold of the children and set the stage for making the study of genetics difficult later in school.

It is a realization of the above causes of children's difficulties in learning genetics and many other crucial reasons, which will be treated shortly, that have prompted this study. For instance the advancement of medicine, development in patterns of life, advances in technology etc. have threatened not only the existence of man but also his whole survival happiness. With the advance in medicine populations have grown, life expectancy has increased thus leading to a depletion of the natural resources which used to sustain human life, in various parts of the world, with no corresponding improvement in people's knowledge of how to improve this disastrous situation (particularly in developing nations). Secondly humanity is beset by more than a thousand diseases and shortcomings that can be traced to changes in hereditary

material (Fried 1971). Fried elaborated this to include 3/4 of the cases of blindness occurring before age of 15, half of the cases of deafness, bone diseases, diabetes, sickle-cell anemia, crippling muscular diseases etc. Paradoxically, the advancement in medicine has increased and will continue to increase the incidence of these diseases. Before the advancement in modern medicine people born with genetic diseases either died at an early age or were severely handicapped in finding wives/husbands and having children. Thus the number of bad genes in each generation was kept at a minimum. Today many people born with genetic diseases often fare well. For instance, a man with sickle-cell anemia can go on taking folic-acid tablets and other drugs and expect to lead a normal life. Or a woman with diabetes can take insulin and expect to lead a normal life, complete with mate and children. Thus the bad genes instead of being kept at a minimum will start to accumulate as the offsprings receive them. Of this situation, Elof Carlson (Fried 1971) stated that "when a load (an accumulation of bad genes) is not eliminated, it expresses itself in heart attacks, susceptibility to cancer, precocious strokes, chronic illness etc." Various other factors or materials have been shown to be injurious to genetic material. For example, drugs such as L.S.D.; tranquilizers, cigarettes and radiation have been reported to cause breakages in chromosome material (chromosomes contain the genes which transmit inherited traits).

The investigator believes that schools should start the study of genetics earlier so that children would be alerted to these problems and dangers. This strategy enables us to expose children early to an education that is based upon information that has survival value for them. This is in tune with the aspirations of the NSTA (National Science

Teachers Association) Curriculum Committee (1964) who stated that:

Education must go beyond the immediate and include the future. It should provide young people with a background and intellectual talents for shaping the future in a manner that assures the welfare of human beings and their progress. Progress is found not so much in tools and material resources as in the extension of intellectual capabilities of people and the viability of their knowledge.... Therefore a curriculum is needed that is oriented toward a period not yet lived, influenced by discoveries not yet made, and beset with social problems not yet predicted.

These statements have significant implications for this study. In recognition of the above issues this study is directed towards identifying children's beliefs about inheritance so that this can serve as a basis for developing strategies of teaching and planning a curriculum on the subject of inheritance for the junior grades in school. An early introduction to the study of genetics has many implications. It would prepare the mind of the young to think constantly about the precarious situation to which advancement has plunged his race. They would think of devising scientific ways of improving the human stock; improving plants and livestock to cope with the growing human population. It is hoped that the early teaching of simple genetics would not only ease the teaching of complex genetics later but will also have prepared the mind of the young for a scientific understanding and approach to the problem of living in a world sophisticated by advancement; this would include refraining from items such as drugs and cigarettes which jeopardize or endanger their life. Also, the early teaching of genetics might stimulate children into a life-long liking for the subject of genetics.

Finally, it is the opinion of the investigator that gaining knowledge relating to children's existing notions about the phenomenon of inheritance would enhance the development of curriculum materials and the teaching of genetics for children with the same thinking abilities and age levels as those that took part in this study.

Chapter 2

LITERATURE REVIEW

Introduction.

This literature review covers the work that has been reported in the areas of development of biology concepts in children and the development of concept of probability or chance in children. This second area may appear to be a sidetrack. However, it is not. In the present study the predictions which the subjects were expected to make in two of the tasks (Tasks IV and Task V) required from them an appreciation of a probability principle in the determination of the offspring characteristics.

The review is made up of four parts. The first part covers Piaget's theory on the process of intellectual development in human organisms. Piaget's theory on intellectual development has become the springboard for many investigations in science concept development. Piaget is made reference to by so many research papers and school materials to the extent that his name has become common parlance in educational circles. Unfortunately, Piaget's theory is subject to differing interpretations. In recognition of this problem this literature review dedicates the first section to the developmental theory of Jean Piaget, in order to clarify the writer's interpretation. The second part of the review covers the work that has been reported in the area of development of concepts in the general area of biology. This part of the review emphasizes the affiliation which most of the work that has been done in the area of biology concept development has for the Piagetian theory. The third section is a discussion of the work that has been done with children in the development of the concept of probability. Piaget again is the pioneer in this area. The fourth part of the review is a critical appraisal by the author

of the work that has been reviewed (especially in the area of biology concept development).

Piaget's Theory of Intellectual Development: "Genetic epistemology is the study of the mechanism of the growth of scientific type knowledge" (Good 1977).

Most research in the development of science concepts have come to use the works of Jean Piaget either as a springboard or a frame of reference. According to Piaget's theory, learning of concepts is a whole life process of dynamic mental adaptation. In this adaptive process the organism is said to interact with the environment in order to develop cognitive structures. This adaptation is comprised of two active components: assimilation and accommodation. Good (1977) states that "assimilation is that part of the adaptation in which the developing organism changes the environment to fit its characteristics. Accommodation comprises those adjustments which the organism undergoes to mentally tolerate the new concept in his (mental) structure". The balance of interplay between these two components in an organism results to equilibration which gives rise to intelligent behaviour (Ohuche 1974).

It is interesting to note that not all types of learning take this form. Some learning takes place in the form of imitation. Good (1977) states that intelligent scientific learning results only when the organism interacts with his environment to adapt his behaviour to reality. This is what Piaget calls self-regulation (Ohuche 1974). Thus, the actions of an organism on his immediate environment become crucial in the process of his acquisition of science concepts. It is on the basis of this learning theory that Jean Piaget developed his famous four stages of cognitive development: sensori-motor stage; preoperational stage; concrete

operational stage; and formal operational stage.

The Literature on Biology Concept Development:

When one examines the present curriculum materials in schools, the teaching and form of learning that is advocated in biology with the emphasis on activity, one realizes the great affiliation the subject of biology or rather science has to the theory postulated by Jean Piaget. However, scanning through the literature one notices that research in the area of acquisition of biology type concepts is limited. The few research papers that are available seem to take two major directions:

- (a) Understanding what young children's beliefs are and the underlying reasons for these beliefs.
- (b) Understanding how curriculum materials fit the 'stages' (Piaget's) which some curriculum designers use as guideposts in developing curriculum for schools. The two 'stages' researchers and curriculum designers emphasize are-
 - (1) concrete operation stage
 - (2) formal operation stage

The earliest research reported for the understanding of young children's beliefs centres around children's notion of life and living things. Piaget identified three characteristics of young children's thinking that tend to dominate explanations of objects and events in their environment (Good 1977). Among these three characteristics (Animism, Artificialism and Magic) Animism was the term Piaget applied to the tendency in children to attribute a consciousness to things such as the sun, moon, trees, stones, air etc. Children believe that these things could act voluntarily. They could move, change colour, sing or whistle when they want to. This animistic concept of life appears to undergo gradual

evolution and then eventually disappears as the child grows. Piaget classified this evolutionary process into four stages:-

- (a) A stage in which the child attributes life to everything which has activity or functions or use of any sort.
- (b) A second stage in which life is defined by movement and all movement being regarded as in a certain degree spontaneous.
- (c) A third stage in which the child distinguishes locomotion from movement imposed by an outside agent.
- (d) A fourth stage in which life is restricted either to animals and/or plants. (Kamara 1971)

Other investigators are reported by Kamara (1971) to have done studies similar to those of Piaget. The findings of these investigators (e.g. Klinberg, 1957; Laurendeau and Pinard, 1962; Looft, 1969) either confirm Piaget's findings or refute them. In the case of Kamara's studies with Sierra Leonean children (in 1971), he found out that there could not be established a relationship between animism and the child's level of intellectual development. He points out that many of the older children who successfully solved the conservation tasks were also found to be highly animistic while many of the younger children were not. With respect to this Laurendeau and Pinard (1962) in their work on Causal Thinking in Children, in which they investigated children's notions of life and living things made the comment that "the scale of stages does not seek to shed light on the accuracy of the infantile concept of life, but rather on the evolution and extension of animistic beliefs."

Another line of investigation which has attracted the attention of researchers is that of young children's concepts of reproduction. Piaget in his book: The Child's Conception of the World (1969) identified two

stages through which a child goes in the course of the development of the thinking concerning the birth of babies. Piaget claimed that these stages are not age specific and both may co-exist at one time although eventually the child will progress from the first stage to the second. According to this theory, during the first stage, the baby is assumed to have existed before its birth and the child merely inquires where it was before birth (Bernstein and Cowan 1975). This belief makes it possible for the child to accept fables told by parents. In the second stage the child questions how babies are made and is led to consider the parents as the cause of their creation. With development, however, Piaget found that the first belief wanes gradually in favour of the more appropriate conceptualization.

Further studies related to the above theory were carried out by Moore and Kendall (1971) and Bernstein and Cowan (1975). As usual with replicated Piagetian experiments, controversies, contradictions and confirmations, as the case may be, are reported by these studies. For instance, the results in the study of Moore and Kendall (1971) provide little support for the Piagetian theorizing about what the child thinks of reproduction. In their study they found that even though children of 2 to 5 years are curious about sex and reproduction, the understanding of these matters does not exist until about the age of 11 years. And from the sample of children they observed, the father's role in the creation of a baby is seen to be inconsequential. This finding is different from that of Bernstein and Cowan (1975) who concluded that their findings "support the hypothesis that children's understanding of human reproduction proceeds through a Piagetian developmental sequence". Many reasons can be advanced for these discrepancies in the results of Piagetian replicated studies, including (a) differences in cultural

background and experiences of the subjects of two or more interview situations (b) differences as well as prejudices among investigators who carry out these studies (c) differences in instruments used and in the methods of analyzing the data collected.

Other research effort in Biology Concept learning has been geared towards understanding how curriculum material could fit the developmental 'stages'. With respect to this stage theory of intellectual development Jean Piaget and his co-workers postulated that the human mind does not show evidence of true logical thinking until the onset of the formal operational stage [usually achieved by age 11 or 12] (Good 1977). Before this stage, the individual can only operate on concrete materials such that his thinking is said to be prelogical. Existing research with children of both stages i.e. concrete operations stage and formal operations stage is centred around classification of biological materials.

The ability to classify has long been regarded as an important aspect of cognitive process. It is based upon the formation by the pupil of precise concepts and the systematic ways of relating them to each other (Lovell, 1968). There are two types of classification dealt with in the literature:

- (a) Classification based on concrete materials. Most of the work that has been carried out in this area has been done with elementary school children.
- (b) Classification based on abstracted thoughts. Most of the work in this area has been carried out with secondary school pupils.

Inhelder and Piaget (1964) working with children on the classification of concrete materials made use of pictures of flowers and animals together

with other objects. This work was to help them understand the process of the development of logical thinking in elementary school children. According to Ryman (1976) Inhelder and Piaget noted a discrepancy between children's ability to deal with classification of pictures of flowers and other objects when compared with tasks making use of pictures of animals. By way of explaining this discrepancy, Inhelder and Piaget suggested that animals, although real (concrete) could not have actions performed on them in the way that was possible with flowers and other objects. Similar discrepancies on tasks involving classification have been reported by other workers. For instance, Kamara (1971) presents evidence that some of his subjects, who even though were taught classification of biological materials verbally by their teacher a week before his investigation, failed to classify a bean seed as a living thing. Presented below is a segment of his discussion.

One week after these children had been taught this lesson, three of them were interviewed as subjects in this study. Surprisingly, the classification of some of the subjects did not reflect any spontaneous recognition of seeds and plants as living things. On the contrary the two subjects who failed to classify the seeds and plants as living things justified their denial of life to these things by arguing that they do not breathe.

Another study on the classification of living things is that of Natadze (1963). Natadze found in his study that children of 7 to 10 years had difficulties in learning to classify common animals, despite very careful help given to them by the investigators. Natadze claims that the children knew the definitions of the organisms supplied by heart, but they were unable to apply them because of inadequate conceptualization. This lead to errors such as insisting that the dolphin was a fish even though they could define its mammalian characteristics.

From studies of 200 children of age 12, tested on classification tasks comprising 38 drawings which are mostly taken from Nuffield text year I, Ryman (1974) made the following conclusion:-

Their understanding of classification was generally poor. With few exceptions, they did not appear to have developed reliable class concepts as revealed by their inability to recognize instances and non-instances of the concepts. The misunderstandings revealed, suggest that inadequate concept formation and language problems contribute to difficulties of classifying plants and animals. It is also possible that the cognitive development of 12 year old pupils is still very much at the concrete level, and tasks demanded of them in classifying plants and animals are too dependent on abstracted thought.

Whereas children at the concrete level of thinking approach a problem in a trial and error manner, testing one thing at a time, rarely arriving at a full solution, those at the formal level make use of a system that takes account of all possibilities. Such a system (Ryman 1976) is only available to the child when his thinking is liberated from the actual objects and classes of objects. Thus for the formal stage the development of classification culminates in a combinatorial system. As an example of a task used at the formal level of thinking, the Woodlouse problem is described below. It is developed in biology after the model initiated by Piaget. Piaget described the combination of ideas or propositions in terms of modern symbolic or algorithmic logic (Ryman 1976). The reasoning behind the model is as follows: when two propositions are considered together so that each can be either true or false, a total of sixteen combinations can be derived by taking the propositions one at a time (4); two at a time (6); three at a time (4); all four together (1); or none (1). The task is built around a diagram (Fig. 1). Questions such as these may be asked of the subjects.

THE WOODLOUSE PROBLEM

FIG. 1

- (1) How would you find out whether the preference of woodlice for darkness is stronger or weaker than their preference for dampness?
- (2) Woodlice are placed in (X) and subjects are asked to list as many possible results as they can think of (Ryman 1976).

Shayer (1974) made use of the Piaget model in his analysis of the Nuffield O-level course materials (Biology). He estimated that the age at which formal thinking appeared was between 13.5 and 14.5 years for able children and around 15 years for children of average intelligence. Children below average intelligence, he further points might never reach the stage of formal thought. Shayer's ages are later than those originally quoted by Piaget and his followers who suggested that the transitions began around the age of 11 (eleven) years. This findings lead Shayer to suggest that several of the activities included in the Nuffield materials were likely to prove beyond the capabilities of many pupils exposed to those materials.

Ryman (1976) in testing for formal thinking in Biology using the woodlouse problem described above concluded that for both first and second year pupils in secondary school, the woodlouse problem seems difficult. And if the woodlouse problem is the (only) yardstick by which formal thinking is measured, then the majority of the children in the first and second year of secondary schooling have not yet attained formal thinking. Ryman further stated that:

It seems unlikely therefore that the problems in the revised Nuffield course will lead to any real scientific solution, where genuine hypothesis are required except for a very small minority of pupils.

Similar results were also obtained by Lawson et al (1971) when they tested

twenty three high school students for conservation reasoning using BSCS Blue Version examination. They concluded that:

The majority of the students in this sample performed below the formal operational level.

Further, they stated that:

The fact that a student does demonstrate conservation, however, in no way seems to insure his success in such a course [B.S.C.S.]. Even the best of conservers performed poorly on the examinations.

However, Piaget's view is that conservation reasoning is a prerequisite for rational (logical) thought and secondly Piaget suggests also that a strong relationship should exist between a student's ability to demonstrate conservation reasoning and his performance on subject matter examination. The investigator on the other hand is of the opinion that conservation may be necessary but not sufficient condition to determine performance on subject matter. Many other factors have to be considered. For example, the socio-economic status and educational level of the home from which the child comes, the patterns of child-rearing, as well as the child's own intellectual ability may all be important factors that go to determine a child's performance in school.

Literature on Probability Concept Development:

In the study of the development of concepts of probability or chance in children Piaget's tasks involved giving each child an assortment of tokens in various colours in an opaque bag. The tokens were shaken well before the child made a draw. An identical assortment of tokens was placed in a row on the table before the child. The child was then asked which colour he would most likely get if he reached into the bag without looking and withdrew one token. (In addition, older subjects

were asked to predict the colours of successive pairs of tokens which were drawn from the bag). Tokens withdrawn from the bag remained on the table in the subject's view (Yost et al. 1962).

From his studies Piaget identified three stages through which children go in the development of concept of probability. In the first stage (5 to 7 years) the child is not able to make his or her predictions consistently on the basis of the quantitative proportions of the elements in the bag, but rather uses various other criteria such as color preference, order of tokens on table etc. Thus a child's predictions in these circumstances do not take into consideration the random mixing of the tokens in the bag and he/she does not consider also the quantitative proportions of the tokens (in the bag). The child at this level of development is said to lack combinatorial patterns of thinking. In the second stage the children (roughly ages 8 to 10) were found by Piaget to base their choices on the quantitative proportions of the elements but fail to consider the implications of drawing tokens from the bag without replacement. The third stage which is made up of children of eleven years and over is the stage in which Piaget claims the children are able to recognize the change in probabilities of the outcome as the number of tokens in the bag decreases.

Quite a few studies have been conducted following a similar procedure to that one developed by Piaget. The findings of some of these studies confirm Piaget's theory e.g. Hoemann and Ross (1971). While the results of other investigators refute Piaget's theory. Examples of these are Davies (1962), Golberg (1966), Yost, Siegel and Andrew (1962) who have reported that under favourable conditions children as young as four years can comprehend and apply probability concepts in making predictions about

outcomes of events.

These controversies exist because in some of these replicated studies the original Piagetian tasks have been altered or modified extensively, even to the extent that reinforcement of the subjects with candies, toys etc. has been introduced. One wonders whether Piaget's original studies in which reinforcements were not part of the protocol can be expected to be the same with studies in which reinforcement is a part of the method of investigation.

The problem of mixing differently coloured tokens in various proportions to check out what thinking patterns the children would bring into the situation of predicting outcome of events has very close resemblance to the problem of predicting outcome of offspring characteristics. In living organisms the genes (from both parents) which go to determine the offspring's characteristic come in various strengths. Some are dominant (over others), while others are recessive. Before these genes assume permanent association with each other to determine the offspring's characteristics, like the tokens, they undergo random mixing (random assortment of genes). It is only after this random assortment that the genes settle down into the various combinations that go to determine the offspring's inherited characteristics. In order to make an appropriate prediction in this circumstance therefore, the subject should have at the back of his mind some idea of: (i) the recessiveness or dominance quality of the genes and (ii) the mixing effect of the genes. It is only when the subject recognizes these two interacting factors which in many ways are similar to the interaction of the two types of tokens in the bag can he predict using a probability (or uncertainty) principle. It is in recognition of this resemblance in the two situations

and the similar thinking patterns the subjects are expected to bring into the two problems that the work on probability has been reviewed to enable the investigator to see what problems there are and what findings have been made in the area of probability. So far the picture emerging in the area of probability concept development is not very clear. These may have been caused by the differing experimental techniques that have been adopted by various researchers who investigate the problem. However, Piaget's study and that of Hoemann and Ross postulate that children develop combinatorial thinking patterns that result to flexible and imprecise predictions about outcome of events at the age of about eleven years. While younger children lack this thinking ability. Younger children seem to be rigid about their predictions; because their thinking most times is centred around the physical properties of the items they are looking at.

Appraisal:

From the foregoing one might tend to believe that the theory of Jean Piaget on cognitive development and its application in the study of Biology in schools is being systematically condemned by the investigator. A belief of this kind is far from the truth. Piaget's theory on cognitive growth has much to offer the Biology educator as well as the learner. It should, however, be cautioned that certain aspects of that theory need reconsideration and even modification. Many of Piaget's advocates misinterpret his writings. Good (1977) points out the concept of 'stages' has been widely misinterpreted due to oversimplification by writers. It would be well advised therefore that the issue of cognitive stages be deemphasized. Many studies in other fields, for example, in the field of physics education e.g. Aguirre (1978), Erickson (1975), Hobbs

(1973), Erickson and Hobbs (1978) point to the fact that many individuals vary in performance from one task to another. Good (1977) reports even of a more serious situation in which he found that over 1/3 (one third) of college seniors he tested failed a paper and pencil test on conservation. With respect to this finding Good commented that "the very possibility exists that many people, perhaps most adults operate at the concrete level". However, caution should be exercised in generalizing the results from a single study to all situations. This scepticism combined with the range of developmental abilities within a single grade level usually at least two or three years, should caution the classroom teacher and curriculum developer against assuming that all or even most children would have attained certain abilities by a given grade or age. Further, it can be emphasized that in the subject of Biology particularly, where curriculum materials have failed to yield constructive results that can be tallied against the cognitive 'stages' of Piaget, the correlation between subject matter and 'cognitive stages' should be discouraged. A more reasonable view of logical development in general is that the rate of development is much slower after a given stage but nonetheless continues. As progressively more difficult situations are encountered, mental structures continue to develop and reach a stable but dynamic equilibrium (Good 1977). Piaget further pointed out that in the development of concepts in children four important factors come into play. He listed these to be: (i) maturation (ii) social transmission (iii) experience (iv) self-regulation. Each of the above factors in various parts of this review has been explicitly or implicitly discussed. For instance Kamara (1971) drew our attention to the case of his subjects who even though had studied

living things in school failed to classify the bean seed as a living thing. These pupils were either not mature or possibly lacked the experience for the tasks presented. A case of social transmission is evidence given by Moore and Kendall (1971) in their study of young children's concepts about reproduction that parents misinform children on these matters. In his paper on Development and Learning, Piaget (1964) emphasized the fact that none of these factors can stand by itself to explain learning. All of these four factors interact with each other to produce intelligent behaviour in the organism.

Finally, the review clearly shows that no work on the development of the concepts related to inheritance has been reported in the literature. This study is therefore one of a pioneering type into the area of heredity concept development among school age Canadian children. There are therefore many problem areas on the topic which one could decide to investigate. This study takes the initial step of discovering first of all what beliefs the children have about the phenomenon of inheritance.

Chapter 3

METHOD FOR COLLECTING DATA

Many methods of research procedure have been developed to study the intellectual development of children at various age levels. These methods are implemented in a variety of formats generally referred to as tests. There are tests for individual I.Q., tests for educational aptitude, tests for achievement and even tests for personality development as it is related to intellectual growth. In discussing the history of tests, Robert McClure (1971) wrote, "they were produced by the score and were rapidly pressed into service in the schools". According to Rugg, quoted by McClure (1971) "there was a veritable orgy of tabulation as surveys studied children in local school systems; took inventories of every conceivable topic and developed batteries of devices to measure educational output". Although the foregoing suggests that there was vast implementation of these tests to understand children's thinking yet these tests contain serious problems as will be outlined shortly. These problems are due to various factors. In IQ tests for instance, the general physical and mental condition of the person taking the test may affect his mental processes in the course of the test. Or even slight illness or mental strain may invariably reduce a testee's score. Or a child from a home in which excellent learning opportunities have been provided may tend always to outrank a less fortunate child who has been deprived of educational opportunities at home. Above all the notion of facing a test causes anxiety among many children and this affects their performance. Further, although these tests have their merits for particular kinds of research they contain serious underlying flaws for others, such as:

- (a) lack of information for the understanding of cognitive operation in learners
- (b) their concern only with answers rather than the process to the answer, which does not aid in shedding light into our understanding of the learning process and the strengths and weaknesses of learners to particular subject areas
- (c) the tendency (in researchers) to brand individuals with learning difficulties as ineducable (on the basis of scores obtained from these tests).

Because of these problems, information derived from these tests may be considered superficial and sometimes useless in the direction of understanding the nature of a child's cognitive operation. Robert McClure (1971) writes of them:-

As in the contemporary period vitriolic argument raged as to the proper uses and interpretations of tests. While the actual and potential paedagogical value of knowing more about the learner was generally recognized, there was bitter disagreement about what specific school policies and practices should follow from such knowledge. There were those who maintained that there was new undisputable proof of the ineducability of at least half of the students and others who concluded that only a fraction of the population had the intelligence and ability to apprehend and utilize traditional academic discipline.

To avoid the situation of labelling individuals, and to furnish an indepth view into the problem (under study) this study adopts a different method - a moderately standardized form of the Clinical Interview Method developed by Jean Piaget. Here as earlier stated the investigator talks freely with the subjects in a set interview protocol, as in this case heredity, listens carefully to their responses while at the same time watches their reactions for further clues. This is very

reasonable because a child's statement or answer to a question cannot be judged on its face value alone. Many factors have to be taken into consideration e.g. culture, experience, etc. Apart from these, Piaget (1969) further points out that a child's response to a question can be (a) romancing (b) random (c) suggested conviction (d) spontaneous conviction, depending on the child in question and the experimental circumstances. All these variables have to be watched for at all stages of the investigation if the study is to yield good and reliable results. It is in recognition of these problems that this research undertook a one-to-one interview situation, so that each child's response would be judged accordingly with due consideration to the factors involved. It is also reasonable to mention here that this method requires a thorough grasp of the techniques of questioning. Thus one sees that an elaborate research method of this kind requires serious precautions on the part of the experimenter both during the interrogation session and in the course of the data processing. Issues such as the following should be carefully considered and taken care of:-

- (a) thorough grasp of the language of communication with the subjects
- (b) objectivity in the analysis of the data as well as an appreciation of children's difficulties
- (c) control of extraneous influences such as noise
- (d) suitability of task materials.

It can only be said in concluding that if one is determined not only to arrive at children's answers but also to probe into their logic and beliefs, there is no other experimental tool more expedient than the Clinical Interview Method.

Schools and Subjects

Thirty two (32) children were selected from three schools in the city of Vancouver. The schools were:

- (1) Chief Maquinna Elementary School
- (2) Queen Elizabeth Elementary School
- (3) Vancouver Technical Secondary School

Since systematic factors such as the location of the schools or the socio-economic status of the subjects' family may indirectly cause bias to the data collected, it was ensured that in order to counterbalance any effect of this type the two elementary schools from which the majority of the subjects came, were to be located far away from each other in differing socio-economic residential areas. This condition was fulfilled since Chief Maquinna Elementary is located in East Vancouver in a moderately low income residential area while Queen Elizabeth Elementary is situated in West Vancouver around the University lecturers' residential area. Further, within each of these schools only alternating grades (odd or even) were used to curtail the amount of interaction among the subjects of different classes during the time of the interviews. Lastly, the subjects were told not to discuss the interview with their classmates until the end of the day, since all four subjects of every grade were interviewed in one school-day period.

The prospective thirty two (32) children that were to be the subjects for the study were each given a letter, seeking permission from their respective parents or guardians for them to participate in the study. The response from the parents/guardians of the children for all the three schools was very good. For a copy of this letter, check appendix 1. The children who participated in the study ranged in age

specifically from 5:6 to 13:10. Two boys and two girls were selected from each grade under the following format.

<u>Grade</u>	<u>Subjects</u>	<u>Total</u>	<u>Approx. age</u>
1	2 boys + 2 girls	4	6
2	2 boys + 2 girls	4	7
3	2 boys + 2 girls	4	8
4	2 boys + 2 girls	4	9
5	2 boys + 2 girls	4	10
6	2 boys + 2 girls	4	11
7	2 boys + 2 girls	4	12
8	2 boys + 2 girls	4	13

The particular age range of roughly 6-13 years was chosen on the ground that it corresponds with school grades in British Columbia when pupils have not yet been exposed formally to the study of Genetics in school.

As the table above indicates there was an attempt made to get an equal representation of the sexes for every grade. This was done to check for and at the same time correct for any beliefs which may be sex-linked among the subjects. Through the help of the respective teachers of each grade the children were chosen on the basis of the fact that they were quite healthy, willing to participate and fell within the group of the average ability children of the class. Apparently, this task was genuinely carried out by the teachers, since some of the subjects asked the investigator during the interview why the "smartest guys" of their class were not considered.

The Tasks

The tasks which formed the basis of the interviews were formally presented to this group of thirty-two (32) children. These tasks went through careful scrutiny some earlier time before this study was formally launched. The original tasks were tried with a group of twelve elementary school children in Vancouver. Incidentally, these children came from quite different schools from the ones used for the study. On the basis of the findings from this pilot study, some of the original tasks were dropped from the list and others were modified appropriately to eliminate all ambiguities and other difficulties.

The tasks were developed from a consideration of the three subject areas which comprise the total representative study of living organisms. Thus, there were tasks on man, animals and plants. Respectively, there were two tasks on man, two tasks on animals and one task on plants. The tasks were designed to determine childrens' belief patterns regarding two major biological conceptions or thinking abilities which are believed to be very fundamental to an understanding and appreciation of genetics in later studies. These conceptions are:

- (1) the ability or inability to distinguish between environmentally induced features and inherited traits on a living organism. In other words, is the subject able or not able to recognize that environmentally induced features cannot be transmitted to the offspring? What beliefs does he/she hold about the phenomenon?
- (2) the ability or inability to recognize that the specific inheritance of an individual child/offspring is not based on any certainty theory or prediction but rather, on probability. In other words, what is the subject's belief regarding the relative

contribution of each parent to a specific offspring's characteristics?

The tests were presented using a series of pictures. Twelve coloured pictures were prepared and all were mounted on hard paper frames of about 10 cm by 15 cm or 15 cm by 20 cm as the case may be. These twelve pictures were presented to each one of the subjects. For one situation a suitable live plant specimen was used instead of a picture.

To go along with these pictures and one live plant specimen, twenty major questions were developed. These twenty questions are presented below along with -

- (a) the rationale for the selection of the phenomenon around which the questions were formulated and
- (b) a distilled summary (where appropriate) of the narrative that was used to present the task situation to the children.

TASK I:

INJURIES ON ANIMALS

Background:

In the course of an animal's life it is faced with many hazards. Motorcars may hit it, and break its leg. Smaller animals like rodents may be attacked by predators and if they are lucky, they may escape with the loss of a body part e.g. tail. Certain lizards (ghekko) show escape mechanism in which they can afford to lose their tails to run away from danger. Animal rearers such as dog owners sometime prefer to shorten the length of the tails and the ears of their animals. In an effort to understand children's beliefs about this phenomenon, as it is related to inheritance, the following task was presented.

Narrative:

The subject was given the picture(s) to examine thoroughly and state what he/she understands from them.

Three dogs (one male and two females) were hit by a motor car while they were crossing the street. These dogs were hurt but fortunately they did not die. They were treated at the Veterinary Clinic nearby.

Questions:

(i) Suppose the leg of one of the female dogs was broken by the car. As a result the dog limps after it became well. Will the puppies of this dog be born with a lame leg? Why?

(ii) The other female dog and the male dog both lost their tails in the accident. If these two dogs have a puppy, what will be the length of tail of this puppy? Why?

(iii) If two dogs (male and female) had their tails cut off at a Veterinary Clinic when they were just one month old, would this affect their own puppies? Why?

(iv) If the tails of all the dogs in Vancouver were cut short by their owners, what will their own newborn puppies look like? Why?

TASK II:INJURIES ON PLANTSBackground:

Plants are subjected by man to various hazards. For industrial supplies of certain dyes, medicine and rubber, the barks, the roots or even the branches of trees are cut off or scraped as the case may be. The wounds as in animals, heal and a scar is left behind which in many cases shows itself right through the lifespan of the plant. Out of wonder for what children's beliefs are regarding this phenomenon and its

relationship to the mechanism of inheritance, the following task is presented.

Narrative:

The subject was shown pictures of wounded trees i.e. rubber tree, douglas fir tree, and African baobab tree and he/she was asked to explain what he/she thinks the men are doing to the trees.

Questions:

(i) If a deep cut is made on the bark of a tree (e.g. rubber tree), will the tree grow a scar?

(ii) If a tree is wounded and it heals its wound, would the scar formed be transferred to the seedling of this tree?

(iii) Suppose a tree has twenty branches and ten of these branches were chopped off, will the scars of these cut off branches show on the seedling of this tree?

(iv) (A live plant specimen was used for this question).

If the leaves of a plant/tree were cut in two halves (demonstrate with a leaf and pair of scissors), when the tree was still a seedling plant, will this affect the shape of the leaves of this plant's seedling?

TASK III:

INJURIES ON MAN

Background:

Human beings, on account of their involvement in various vigorous or risk-taking activities in their every day undertakings, are themselves also subjected to a variety of hazards in which many get injured and lose a body part or its effective functioning completely right through life. What do children think about this situation in relation to what an

offspring can inherit from its parents?

Narrative:

The subject was given pictures of two crashes; a motorcar crash, and a train crash and was asked to explain his observation.

Questions:

(i) Suppose in a train accident a man lost one of his fingers/toes. If this man has a child, how many fingers/toes will the child have?

(ii) Suppose a man and his wife both lost their thumbs/fingers in a train accident. If they have a child afterwards, how will this child be?

(iii) Suppose another couple were injured in a car accident in which they lost their eyesight. If they have a child afterwards, will this child be affected?

(iv) Suppose a small boy and a small girl lost their fingers when they were just babies e.g. 1 yr. old. If they grow up, get married and have a baby, will their baby be affected?

TASK IV:

HEIGHT IN MAN

Background:

Man, plants and animals exhibit inherited qualities. In these organisms inheritance follows a similar pattern i.e. the genetic code present in the gametes of either parent is transmitted to the offspring during fertilization but with varying degrees of manifestation or appearance especially when predictions are based on an individual case. Thus, predictions which are couched on non-probabilistic premise or without any gist of uncertainty are viewed with suspicion. How do children make their own predictions about the phenomenon of inheritance? What is their explanation?

Narrative:

The subject was presented with the pictures for observation and comments.

Questions:

(i) If a tall man and a short woman have a child. If this child is a boy, how tall will he be when he is fully grown?

(ii) If the child is a girl, how tall will she be when she is fully grown?

(iii) Why do you say so?

(iv) Do you know of any other things which could make a child grow tall?

TASK V:COLOUR IN DOGSBackground:

Same as in TASK IV.

Narrative:

The subject was given a series of pictures of dogs and puppies for observation and comments.

Questions:

(i) If a black dog (female) is to have puppies, what colour would the puppies be?

(ii) If a white male dog and a black female dog have six puppies: What colour would their puppies be?

(iii) Which one of the parent dogs do you think would give more colour to the puppies? Why?

(iv) Can the puppies have any other colour apart from the colour of the parent dog?

It can be seen from the above layout that the first three tasks address themselves directly to the first of the two objectives which is to find out whether or not the subjects can distinguish between environmentally induced features and inherited traits. The last two tasks address themselves to the second objective which is to find out whether or not the subjects are able to invoke a probabilistic thinking pattern in predicting the offspring's inherited phenotypic traits. It may also be noticed that each of the concepts that was investigated was presented in two or more different settings. This was done to find out whether the subject uses the same prediction or explanation he/she adopted in previous instances. This was deemed the only way to check for the stability of reasoning which would be typical of subjects who show comprehension or appreciation of a systematic mechanism of inheritance both within and without each of the subject areas treated.

The Interview Setting

The interviews were conducted on the premises of each of the three schools that participated in the study. Each school provided a quiet room with as little disturbance as possible from outside. An audiotape-recorder was set in the room well before the commencement of each day's schedule.

Each child was interviewed alone in the room for a period of about 30-40 minutes. It was ensured that the child was comfortably seated and facing the investigator. In the preliminary talk between the subject and the investigator, the subject was made aware that his or her response was being recorded by audiotape. He/she was also assured that the discussion between him/her and the investigator would not be made known to anyone, neither the teachers nor his/her parents. Each of the subjects was

assured to feel free to say whatever came to his/her mind regarding the questions posed and that he/she should try to be as sincere as possible about what he/she says. And then some biographical data regarding the subject's name, age was collected.

The formal aspects of the interview involved exposing each of the subjects in the sample to the same experimental setting: - this includes exposure to the twelve series of pictures plus one plant specimen, sequentially followed by the set of twenty questions which were posed by the experimenter. These twenty major questions were followed by probings for clarifications or elaborations. The discussion which ensued from this interaction made up the raw data for this study. In the course of the interview, particular attention was paid to the ideas and the language patterns used by the subjects. These ideas and linguistic patterns served as the 'life cord' which the interviewer held on to, in order to sustain the spirit of the interview.

Chapter 4

ANALYSIS

The Method.

The four questions which comprise each task were presented to the subjects in the format in which they are shown in the previous chapter. From this plan it could be observed that the factors which were suspected to be significant in terms of having influence on the subjects' responses were introduced into the questions in a very orderly fashion, one after the other. A few questions were not asked; especially those to which the subject implied the answer in a previous response. The response to each question is made up of two parts: a prediction part and the statement of support or explanation. These predictions and explanations formed the basic data for this analysis.

The data were analyzed using tabular techniques. For every task there are two types of tables i.e.

- (a) Question - Response table: These Question-Response tables are labelled 1AI to 5AVIII. They are presented in the Appendix II.
- (b) Frequency Distribution table: The Frequency Distribution tables are labelled 1BI to 5BIV. They are presented in the text of the Analysis.

The Question-Response tables show, as the name implies, the responses to the questions grouped by age, for all the subjects who participated. From these tables, one can see the actual answers given by each child to the twenty major questions that were asked. (The probings and the corresponding responses to them were not recorded in the tables). The Question-Response tables perform two functions. First, from them, one can see clearly how the responses of the subjects progress from age to

age. This can easily be done by reading each column downwards for a given question. The second function is to show the prediction and explanation of every subject to the four questions making up the task. By reading horizontally across each child's name, one can see whether the subject is giving consistent responses as the different situations of the task are introduced into the questions.

The Frequency Distribution tables, labelled 1BI to 5BIV in the text are only concerned with the predictive part of the subjects' responses to the questions. For every question, a table of predictive responses is presented. The table shows how the subjects' predictions are distributed along the age groups. Wherever it was deemed appropriate the predictions have been compressed bearing in mind the major ideas expressed by the subjects. From these tables also one can see whether particular predictions seem to emerge only at particular ages or not.

A categorization system was developed for the explanations of the subjects. Five categories were developed based on the kinds of explanations the subjects invoked for the determination of the offsprings' inherited characteristics. These categories are:

Environmental.

When the subject invokes environmental things to be responsible for an inherited trait in an offspring. For example the subject may claim the sun, the water, etc. to be responsible for determining the outcome of an offspring's inherited characteristic.

Somatic or Organismic.

When the subject invokes a part of the parent's body (vegetative) as the agent responsible for determining the characteristic of the offspring. For example the brain, the blood, the branches, the teats

are claimed as the determinants of the offspring's inherited characteristics.

Naturalistic.

When the subject invokes 'biological' but unscientific reasons for the origin of an offspring's characteristic. For example, the subject may claim that the offspring would look like its mother because it is a girl (female). Or that it would look like its father because it is a boy.

Heredity.

When the subject invokes a biologically scientific origin for the inherited characteristics of the offspring.

Heredity and Environment.

When the subject invokes a biologically scientific reason for the origin of the inherited trait and is also aware that the trait could be influenced by environmental conditions.

The whole Analysis is made up of five sections. These sections are:

- (a) Analysis for Task I
- (b) Analysis for Task II
- (c) Analysis for Task III
- (d) Analysis for Task IV
- (e) Analysis for Task V

Task I

In this task the children were presented with a picture of three dogs and were told a story about an accident in which the dogs were involved. The questions which followed the story were designed to check out whether the deformity left by the injury would be transmitted to the offspring. And if this is or is not the case, whether the presence or absence of certain factors or situations would alter the results. The factors introduced are:

- (1) Number or sex of parents injured. The subjects were asked whether it would make any difference if only one or both parents of the offspring were injured. And whether it would make any difference whether the male parent or the female parent were the one who was injured.
- (2) Time elapsed. The subjects were asked whether it made any difference if the parent had the child a short while after the accident or many years after the accident [injury].
- (3) Population magnitude. The subjects were asked whether it made any difference if only a few members of the population of animals were injured or if all the members of the population sustained the same injury.
- (4) Repeated injury. The subjects were asked whether inflicting an injury on members of a population of animals, generation after generation, would change the traits of that population.

The fourth factor or situation i.e. repeated injury, was presented in the course of the probing immediately following Question III or Question IV. These four factors or situations though unimportant in terms of the real outcome of the situation, were found to have influence on the subjects

as manifested by their responses. However, a casual observation of tables 1BI to 1BIV appears to show the same distribution exhibited by the predictions of the subjects from Question I to Question IV. A closer study of these tables reveals that this is not exactly the case. The number of children giving the less appropriate response increases from table 1BI to 1BIV.

Question I:

Suppose the leg of a female dog was broken by a motorcar.

If this dog limps after it has become well. Would the puppies of this dog be born with a lame leg?

For this question there were fourteen subjects who predicted that the puppies would limp. Eighteen subjects said the puppies would not limp. Among the fourteen subjects who said that the puppies would limp, there was no child from the thirteen year olds; only very few from the group of eleven and twelve year olds. Dividing the distribution of subjects into two groups: six to nine year olds as younger and ten to thirteen year olds as older, one sees that seven of the younger children predicted that the puppies would limp; while thirteen children said they would not. On the overall, within these two groups - younger and older, more of the younger children predicted that the puppies would limp while more of the older subjects claimed the puppies would not limp.

Checking the Appendix on Question-Response, tables 1AI to 1AVIII, the children in these two groups, gave various reasons to support their claim. Presented below are a few of their statements.

<u>Prediction</u>	<u>Table #</u>	<u>Subject</u>	<u>Explanation ; Because</u>
Pups will limp	IAI	Johnnie 7.4	the mother broke her bone.
Pups will limp	IAII	Douglas 8.1	whatever the mother is, the baby will be.
Pups will limp	IAIV	Shannon 10.2	(but) it depends on the father.
Pups will not limp	IAI	Tricia 7.5	they're different part of the mother.
Pups will not limp	IAII	Hughie 8.6	it happened to her, not them.
Pups will not limp	IAVIII	Walter 13.8	it's not natural, it happened by car.

Question II:

If two dogs (male and female) had their tails cut short in an accident, if they have puppies, how would these puppies be in terms of tail length?

Two new factors were introduced in this question. These factors are the additon of a father to the mother dog (of Question I) and the complete removal of a body part unlike the case in the previous question where it was just the breaking of a leg. The pattern exhibited here by the scores (see table 1BII) appears to be similar to that for Question I. However, there are small variations in that those children who claimed that the puppies would be born with a short tail are fifteen and those who said they would not are sixteen. The one subject who said she does not know claimed that she has a dog with a short tail but that this dog is a 'boy' [male]. "Of course boy dogs don't have puppies". To this child, Christina (5.6) the question of introducing the male factor is unwarranted since for her, male parent dogs are not involved in

FREQUENCY DISTRIBUTION TABLE

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A G E

QUESTION:

6 7 8 9 10 11 12 13

Suppose the leg of a female dog
was broken by a motorcar. If
this dog limps after it has
become well. Would the puppies
be born with a lame leg?

RESPONSE:

TOTAL:

Yes. They would limp/have a scar etc.	111	1	11	1111	1	11		14	
No. They would not.	1	1	1	11	111	1111	1	11111	18

FREQUENCY DISTRIBUTION TABLE

1BII

A G E

QUESTION II:

If two dogs, (male and female) had their tails cut short in an accident, if they have puppies, how will these puppies be in terms of tail length?

	6	7	8	9	10	11	12	13	TOTAL
With a short tail/without tail etc.		11	11	11	11111	11	11		15
With a normal tail.		111		11	11	111	1	11111	16
I don't know.		1							1

FREQUENCY DISTRIBUTION TABLE

1BIII

A G E

QUESTION III:

If two dogs lost their tails just
when they were little pups, if
they have puppies when they are
fully grown. How will their puppies'
tails be?

6 7 8 9 10 11 12 13

RESPONSE:

TOTAL

Born with short tails/no tails.	111	11	11	11111	11	11	1	17
Born quite normal.	11		11	11	111	1	1111	14
I don't know.	1							

FREQUENCY DISTRIBUTION TABLE

1BIV

A G E

QUESTION: IV:

If the tails of all the dogs in
Vancouver were cut short by their
owners, what will their newborn
puppies look like?

6 7 8 9 10 11 12 13

RESPONSE:

TOTAL

With a short tail/no tail.	1	11	11	11	11111	11	11	11	18
With a normal tail.		11		11	11	111	1	111	13
I don't know.		1							1

determining what inherited characteristics the puppies would have.

The fifteen-sixteen-one distribution shown in table 1BII illustrates to some extent that the introduced factors have had some effect on the subjects. A closer study of the distribution of the two groups of children in table 1BII shows that among the younger children, six claimed the puppies would be born with short tails while five said they would not be born that way. One child in this group said she did not know. In the older group of ten to thirteen year olds, nine children said the puppies would be born with abnormal tails and eleven claimed the puppies would be born normal. The relative differences between the number of children opting for either of the two options in both the younger group and older group is too small as yet to justify the making of any strong statements about increases or decreases in the number of children (opting for one or the other of the two choices). However, one postulation can safely be made that the introduction of the new factors revealed some inconsistency in the minds of some subjects as shown by the differences between the score ratios of tables 1BI and 1BII. Those children who gave conflicting answers were probed as to why they had taken different positions. Some of them had no strong reason, while others gave very interesting defensive statements. The case of Johnnie (7.4) is presented for illustration.

E : Have you seen dogs without tails? Dog whose tails have been removed?

S : Yes.

E : In this accident, these two dogs' tails were run over by the car.

They were taken to the veterinary clinic for treatment. They became well but had no tails anymore, as the dog in this picture. If these two dogs have puppies after some years, how will their puppies be:

with a tail or without a tail?

S : The puppies will have a tail.

E : Why will they have a tail?

S : The car ran over the dogs' tail but it did not run over the babies, so the little pups will have a tail.

E : Earlier on, you told me that if the foot is broken, of a dog; and then the dog has puppies, you said the puppies will also have a broken leg.

S : No. I said they will limp.

E : Oh, O.K. What will make them limp?

S : Because they will walk bad like their mother.

E : Will they have a broken leg?

S : No.

It seems evident from Johnnie's statement that the acquisition of the limp by the puppies is an environmental phenomenon. Mere imitation is a mechanism sufficient by itself to result in the acquisition of a trait. For him hence a limp can be mimicked but a cut tail cannot, the limp would be transferred to the offspring but not the cut tail.

Question III:

If two dogs lost their tails while they were just puppies, if they have puppies when they are fully grown, how will their own puppies be?

The distribution of the subjects by response to this question (see Table 1BIII) show an increase for the number of children claiming that the puppies would be born with a short tail. The new factor that was introduced in this question is the factor of 'time elapse'. Seventeen

children said the puppies would be born with abnormal tails. Fourteen said they would be born normal. So with the introduction of more factors we find more children getting deceived and giving the inappropriate answer. One subject said she did not know the answer. A closer examination of the two groups of children - younger and older, shows that seven of the younger children chose the option that the puppies would be abnormal while only four said the puppies would be normal. For the older group ten subjects said the puppies would be born with short tails while the same number of subjects (ten) claimed the puppies would come with normal tails. Thus it could be seen from the consistent reduction of number of children giving the more appropriate response (both from the younger and older group) that the introduced factors or situations are having some influence on some of the children regardless of age. Even one thirteen year old was deceived. The typical responses given for the significance of time elapse are: Jun (10.6): "the dogs have a short tail for a long time so it will be in their system." Marla (10.11): "the mother has had it for a long time." Walter (13.8): "they [parents] were small when it happened to them so they would inherit the short tail as they grow up." (See also Table 1AV and 1AVIII in Appendix).

Quite a few of the children were reminded again about how their responses conflict with their earlier answers. It is surprising to notice that some of these children still remained oblivious of the changes they made in their responses as the interview progressed in spite of the constant reminders from the interviewer. Jamie's (7.4) case is presented. See also Table 1AI in Appendix.

E : If the dog's tail was cut off when it was very young, when it was a puppy. If this puppy grows up and has its own puppies. Will its own puppies have a tail?

S : No.

E : But earlier on, you said that dogs' tail are usually not cut off in accidents, but even when the tails are cut, their own puppies will have tails. Why are you changing [your view] now?

S : I do not know I am changing but I think that it is rightm.... maybe it is wrongbut...it is.

It seems quite clear from Jamie's answer that he is quite convinced that the puppies will not have a tail as far as this instance is concerned.. The reminders of conflict by the experimenter only signalled to the subject that the experimenter is saying 'you are wrong'. This specific interaction is very significant in terms of the light it sheds on children's thinking. In a nutshell what Jamie reveals from his last statement is that what could be wrong to one's perception as an adult may not necessarily be wrong to a child's judgement. A child and an adult operate at two different cognitive levels, hence Jamie's statement - "maybe it is wrong....but....." to him it is correct. This is a fact to be reckoned with if our goal in schools is to have a successful interaction with children.

Question IV:

If the tails of all dogs in Vancouver were cut short by their owners,, what will their newborn puppies look like? Why?

In this question the factor of large numbers [population magnitude] was investigated. The results show that this factor was very significant in terms of the effect it had upon the responses of the subjects. From

Table 1BIV it is observed that eighteen subjects predicted that the puppies born of the short tailed parents would be with short tails. Thirteen subjects said this is not going to be the case. One child said she did not know the answer.

Among the younger children i.e. six to nine year olds, seven opted for the response that the puppies would be abnormal. Four subjects in this group claimed the puppies would be normal. In the older group of children eleven said the puppies would be born with a short tail while nine subjects said this is not so; the puppies would be born normal. According to these figures only a very small number of children changed their answers from what they said for Question III. In fact those children who said the puppies would be born with abnormal tails were very firm this time about their belief. Sergio's case (12.6) is presented for illustration. See also Table 1AVII in Appendix.

Sergio (12.6): The puppies would be without tails. Pretty sure about that, since all the dogs in Vancouver did not have any tails, their puppies will not; for ever and ever no dog would have any **tails!**

This question was extended one step further in that the subjects were asked what would happen to the tails of the puppies if people should go on cutting the tails of the parents from one generation to the other. Although the responses are not formally presented in the tables as for the other questions, mention of them is made where appropriate and instances reported in the commentary section of the tables (1AI-1AVIII in Appendix). It should be mentioned that many subjects fell prey to this extension: they predicted that the tails will progressively get shorter and shorter until there is no tail anymore and dogs would

remain that way, without tails. For typical cases see responses of Vivian (13.00) and Liza (13.5) in Tables LAVIII and LAVII respectively in the Appendix.

Summary of Task I Analysis

A large proportion of the children, six-thirteen years, have the misconception that deformities resulting from injuries can be transmitted by a parent to the offspring. The number of children who had these kinds of beliefs increased progressively as the factors of two parents, length of time, large populations, repeated cuttings, were introduced into the questions.

Although the children were divided into two groups - a younger group (six-nine years) and an older group (ten-thirteen years), the misconception was found to be present in all the ages. Each of the factors that was sequentially introduced affected some children of all the ages studied. Some of the children in trying to explain their various answers to the questions have brought in their own experiences with dogs, what their relatives have told them, films, school readings etc. From their answers it would be seen that some of these experiences have helped while others have failed. Those children who have had concrete experiences of tending dogs with cut tails, especially in the case where these dogs are females, seem to be far more consistent in their predictions than those who have read or casually heard about mutation or the evolutionary theory of man developing from other primates. In fact some of these experiences have only added more confusion to the minds of the children.

For example Vivian (13.00) says -

"but if they keep on doing that (cutting the tails) long in time, it might---mutation---you know."

Shannon (10.2) "I saw a show (movie) of a lady without arms but her own baby had arms. This could have been because of the father."

Liza (13.5) "Their puppies will be born with short tails. We are supposed to be born of the monkey and we only have a tail bone now".

Further some children have invoked environmental explanations such as mimicry for the acquisition of a trait. Others have invoked somatic or organismic explanations such as "the system of the parent", "the nervous system", etc. Other children have given naturalistic explanations such as "whatever the mother is, the baby will be". Yet some children have given hereditary explanations such as "they are a special breed, so we have to cut their tails too".

Although some of these explanations are inappropriate in the context in which they have been used, they shed light on what these subjects' beliefs are regarding the phenomenon of inheritance. As far as this task was concerned there was no specific age at which the specific beliefs or concepts emerged. All the age groups of children who participated in the study had difficulties and successes with the task. It could be concluded therefore that the concept checked for in this task may not be consistent with a development sequence. Rather it may merely be dependent on the respective experiences which the individual child has had. Even some of the very young children (Tricia 7.5) were not deceived by any one of the forms in which the task was presented. On the other hand some thirteen year olds were. One very significant need which has been expressed by the various reconstructions of the children is that they are very curious to know about the phenomenon of

inheritance. Hence appropriate learning experiences have not been made available to them to satisfy this yearning, they on their own, are devising whatever formulations that come to their minds in order to cope with the situation.

TASK II

Task II was presented to the subjects in 4 stages as in the previous Task. For three of these stages, pictures depicting various circumstances in a plant's life were presented to the subjects. In the fourth stage a live plant specimen was used. This Task as a whole was included in the study in order to find out whether children do realize that the mechanism of inheritance as manifested in animals follows a similar pattern in plants as well.

Question I:

If a deep cut is made on the bark of a tree (e.g. a rubber tree). Will the tree grow a scar?

This question was asked in order to distinguish between those children who have an understanding of the fact that plants can grow a scar when their barks are wounded and those children who lack such an understanding. And from merely glancing through Table 2BI, it is quite clear that the majority of the children from both the younger (6-9 years) and the older group (10-13 years) have an understanding that plants do grow scars when their bark is wounded. Only two children among the younger group of children said they do not believe the phenomenon is possible. To them plants cannot grow a scar. Only one child among the older group of children had difficulty with the task. It is in fact even surprising that a child in this age group should have a problem with this question at all. But taking a closer look at his explanation in Table 2AVIII (Appendix) one sees that this subject's problem is only one of semantics (see Walter (13.8) Table 2AVIII). For Walter explained his position by saying that he himself wounded a tree which is standing just in front of his house. And for the past five years

he has been watching the tree, the wound is still there but the outer skin is dry and not fresh. However, he cannot refer to this phenomenon as a scar. So one sees that Walter's problem is not with the concept but rather is with the linguistic application of the word 'scar' to plants. As implied by his argument, he may have learned to use the word 'scar' only in animal and human circumstances and not in the context of plants. Hence Walter's problem was only one of language. He was asked the accompanying questions that comprise the Task, with the investigator making appropriate 'wording modifications' to suit this subject's framework. The other two children, Christina (5.6) and Jamie (7.4) (see Table 2AI) who denied flatly that plants cannot grow scars because 'they are not human beings' were not asked further about the phenomenon. Their score in Table 2BII, 2BIII, and 2BIV is recorded as 0 (zero).

From the total score ratio in Table 2BI which is presented as 3-29, it is quite clear that the majority of the children knew what the concept, checked for, was. That is 29 children said the tree will grow a scar, while only 3 said the tree lacks such capability. It was these 29 children plus Walter who were exposed to the subsequent three questions.

Question II:

If a tree is wounded and it heals its wound, would the scar formed be transferred to the seedling of this tree?

In this question the children were shown two pictures of men inflicting wounds on the barks of two different trees, a rubber tree and a douglas fir tree. From observing the distribution of scores in Table 2BII, one notices that only 3 children said that the scar will be transferred to the seedling plant while 27 children said this is not the case. It is

FREQUENCY DISTRIBUTION TABLE

2BI

A G E

QUESTION I:

If a deep cut is made on the bark
of a tree (e.g. a rubber tree).
Will the tree grow a scar?

RESPONSE:

TOTAL

	6	7	8	9	10	11	12	13	
No, It won't grow a scar.	1	1						1	3
Yes, it would grow a scar.		1111	11	1111	11111111	11111	111	1111	29

FREQUENCY DISTRIBUTION TABLE

2BII

A G E

QUESTION II:

If a tree is wounded and it heals
its wound, would the scar formed
be transferred to the seedling of
this tree?

6 7 8 9 10 11 12 13

RESPONSE:

TOTAL

Yes, it would be transferred.					11		1		3
No, it would not be transferred.	1111	11	1111	11111	11111	11	11111		27

FREQUENCY DISTRIBUTION TABLE

2BIII

A G E

QUESTION III:

Suppose a tree has 20 branches and
10 of these branches were chopped
off. Will the scars of these chopped
off branches show on the young seedling?

RESPONSE:

TOTAL

Yes, the scars will appear on the
seedling.

11 1 11 11 1 8

No, the scars won't appear.

11 1 11 11111 11111 11 11111 22

FREQUENCY DISTRIBUTION TABLE

2BIV

A G E

QUESTION IV:

6 7 8 9 10 11 12 13

If the leaves of a tree were cut
in two halves (demonstrate with a
leaf and scissors) when the tree was
still a seedling plant, will this
affect the shape of the seedling leaves
of the tree?

RESPONSE:

TOTAL

Yes, the shape of the leaves of the
seedling would be affected.

1 11

1

4

No, the leaves won't be affected.

111

11

111

11111

11111

11

11111

25

I don't know.

1

1

rather surprising that these 3 children come from the group of older subjects (10-13 years). Two of these subjects who said the scar will be transferred explained that only a small part of the scar, commensurate with the size of the seedling, will appear. For this group of subjects as the seedling grows bigger and bigger so the scar grows larger and larger too (see Table 2AV for Stephen (10.9) and Table 2AVII for Sandra (12.8). The third child in this group explained his position using the factor of Time, even before the investigator could introduce the question related to that situation. So in fact his response to Question III was merely implied from his response here. The following interview segment is presented for illustration of the subjects' statements: Jun (10.6). "If the wound was done before the seeds are on the tree, then the scar would be given to the seedling. But if it is done when the seeds are already there it would not be given into the seeds". (See Table 2AV).

Among the 27 subjects who predicted that the scar of the parent plant would not be handed down to the seedling three, there was a very good representation from the younger group and the older group of subjects. These 27 children have given varying explanations to support their predictions. Some in fact in their denial of the transfer of the scar have made reference to what they said earlier about the dogs in Task I. Tony (12.6) "The seedling won't have a scar. It is something like that - the dog".

Within this same group also other children have used a purely somatic or organismic explanation that the seed was not conceived inside the parents plant's body, so because of that there is no way this condition could affect the seedling. These kinds of explanations came especially from those subjects whose prediction in this question conflicts with their

prediction in the case of the dog. Susan's (11.1) interview excerpt is one illustration of the case in point.

E.....will this scar be transferred to the young plant or will it not not be transferred?

S : No. I don't think it will.

E : Why will it not be transferred?

S : Because it only happened to this one (parent). A person came and peeled it off.

E : Why is it that in this tree the scar is not transferred, but in dogs it is transferred?

S : Because it is just seeds coming out...like... some one is taking them away.

E : What do you mean exactly?

S : They don't grow in the tree, some one's got to plant them away from this tree.

(See also Eric (11.10) Table 2AVI)

Yet, there are quite a few subjects within this group of children who gave a different version of the somatic explanation. They said that since the tree was not wounded on the branches which hold the seeds, the seeds are then too far away from the wounded stem to get the effect of the wound. So for these subjects "proximity" of the developing seeds to the wounded part of the tree is the important factor to be considered for the determination of whether or not the scar would be transferred to the seedling. The further away the wound is from the location of the seeds, the less the chance for transfer; the nearer the better.

Question III:

Suppose a tree has 20 branches and 10 of these branches were chopped off. Will the scars of these chopped off branches show on the young seedling of this tree?

In this question the variable of the 'proximity of the seeds' to the injured part of the tree which some of the children mentioned in the data of the last question (i.e. Question II) was checked for on the other subjects.

As can be seen from the score ratio in Table 2BIII, 8 subjects claim that the scars will be transferred to the seedling while 22 said the scars will not be transferred. From the explanation of some of these subjects, it appears quite a few of them did not look at the phenomenon from a 'proximity to injury' point of view, rather they looked at it from a 'permanence of scar' point of view. That is, for these children since the wound on the bark would grow a new skin and conceal the injury, the resultant scar will not be transferred as the injury was only temporary. A new skin would grow in and cover the area. But in the case of the cutting down of the branches, the scars remain permanently on the parent tree right through its life span. Because of this permanent manifestation of the scars in this type of injury, these children believe that the scars left behind will be transferred to the seedling tree from the parent tree. For examples of these kinds of response, see Hughie (8.6), and Brenda (7.8) in Table 2AII.

Although the factor of 'proximity' was initially introduced by subjects from the older group, as already explained in the analysis for Question II, this factor when formally instituted in this Question III, had effect to a large extent among the younger group of children (6-9 year olds). The

cases of Brenda and Hughie mentioned above testify to this statement. Five of the 8 subjects who said the scars will be transferred are from the 6-9 year olds. And among this group of young children also only 5 predicted that the scar will not be transferred to the offspring tree. While in the older group of subjects 17 said the scar will not be transferred and only 3 said the scar will be transferred. These 3 subjects in fact are the same ones who said in Question II that the scar will be transferred to the seedling. So according to this data then, the 'proximity' variable did not have a very significant effect in changing the already implanted concepts of the older children except for the 3 cases which have already been talked about. Those children who are deceived by the introduced variable, 'proximity' had basically the same reason, except for the subjects who gave a 'permanence' explanation, for saying that the scars on the branches will be transferred. The statements of Micahel (9.2) (see Table 2AIII) exemplify these children's difficulties.

"If the branches are removed, this (scar)
will be transferred to the seedling.
Because this is now cutting down branches."

Question IV:

If the leaves of a house plant were cut in two halves (demonstrate) when the plant was a seedling, will this affect the shape of the leaves of the seedling tree?

In order to find out whether the variable of time elapsed would have any effect in influencing the beliefs held by the subjects regarding the transmission of inherited characteristics from a parent plant to an offspring plant, the above question was presented to the subjects with a concrete demonstration of the task done by the investigator in front of the subject. With the use of a pair of scissors, the investigator cut up one or two

leaves of a young potted plant into two halves and asked the subject whether the action demonstrated would affect the shape of the leaves of the seedling that would develop from the seeds of this potted plant.

As could be seen from Table 2BIV, only 4 children said that the cutting of the leaves of the parent plant would affect the shape of the leaves of the seedling. Three of these children are from the older group. These 3 older children are in fact the same subjects who have been saying all along that the plant's deformities would be transferred. Thus, it can be seen that although these subjects are wrong, they have been consistent in their prediction.

As a whole 25 of the subjects said the cut on the leaves would not affect the shape of the leaves of the seedling. Eight of this group of children come from the younger group while the other 17 children are from the older group of children. One child said he did not know the answer to the question.

In this task a small variation was made in that the variables of sex and the number of the parents contributing to the offspring's characteristics, as was the case in Task I, was omitted. This became necessary because the Pilot Study revealed that the children did not recognize the importance of these variables as they are applicable to plants.

Summary

It would appear from the very low frequency of the children in this task who claim that the scar would be transferred, that the concept checked for by the Task was well established in the minds of the subjects who were studied. But, from probings of some of the subjects, it became quite evident that even though the majority of the subjects gave what would be called 'acceptable' predictions, these answers were not, except

for a few cases, based on any understanding of the genetic principle which is operating and responsible for the non-transfer of the scar. Some of the subjects clarified their present different position for this Task from their position for the previous Task on dogs, that plants and animals are not the same organism, implying they are not operating under the same genetic mechanism. To this end Jamie (7.4) says:

"There is only one thing which animals and plants do the same. They both drink water."

The factors that were introduced, i.e. the factor of proximity and permanence, had varying degrees of effect on both age groups. However, only 3 children from the older group as opposed to 5 children from the younger group yielded to the deception of these factors. The misconceptions then were present in both the older and the younger group of children.

The factor of time elapsed did not seem to have much effect on the subjects since many of them said that the tree will grow new leaves again with good shape in place of the injured ones (see Table 2BIV for the scores).

On the whole the majority of the subjects predicted for this task that the seedlings would not be affected. But inconsistency was revealed in both groups of subjects by their responses when the factors of 'proximity' and 'permanence' were introduced. Thus, the 'acceptable' predictions did not seem to be based on an understanding of the underlying principle of inheritance.

TASK III

Task III was developed in order to find out what belief patterns the children have regarding the phenomenon of inheritance in human beings.

The four questions that comprise this Task were presented to the subjects in the same format as in the earlier tasks. The first two questions arose out of a picture of a train accident. The second two questions were developed from a picture of a car wreck.

Question I:

Suppose in a train accident, a man lost one of his fingers.

If this man has a child, how many fingers will this baby have?

In this question only the factor of the male partner was presented to the subjects. The female factor was withheld. The total score for this question on Table 3BI shows that 7 of the subjects said the child would have fewer fingers. Of these 7, 5 subjects come from the younger group of subjects (6-9 years), while the remaining two are from the older group (10-13 years). Twenty-three subjects predicted that the child will be born normal. The majority of these 23 subjects come from the older group of children. In fact, no child within the sample of children who participated showed signs of the misconception after the age of 10. However, 5 of the 23 subjects who claimed the deformity cannot be transferred to the child come from the younger group. These figures are suggestive indeed but a closer study reveals that they portray a slightly different picture from what the facts are. This is because the arguments that were advanced by some of the 23 subjects were not indicative of an understanding of the underlying mechanism. Some claim that because it is the man who is involved the child would not be affected since it is the woman who bears the babies. A few subjects' interview segments are presented to

illustrate the point.

Susan (11.1) "I think the baby would still have ten - like five on each hand. It should not affect the baby, because it happened just to the man and the lady had good fingers."

Douglas (8.1) "A man does not have babies. But if he has a wife with normal fingers, one child would have (five) fingers like me."

Jamie (7.4) "Men? Men cannot have babies. No."

However, most of the 23 children comprising this group had clear notions about the phenomenon. A case from the younger group of children is presented to exemplify the other subjects' form of thinking.

Tricia (7.5) "The baby would just be as someone who did not have any fingers cut off. So it won't affect the child."

The above indicates that both forms of thinking patterns are present in both the age groups of subjects that participated.

Question II:

Suppose a man and his wife both lost their thumbs/fingers in a train accident. If they have a child afterwards, how will the child be?

In this question the female parent was introduced into the scene in order to see what effect this new factor would have on the subjects' prediction. As reported in Table 3BII, 12 subjects said the child will be born with fewer fingers. Of these 12 subjects, 6 are from the younger group (6-9 years) and the other 6 are from the older group of subjects. Nineteen children predicted that the child would be born normal. Five of these

FREQUENCY DISTRIBUTION TABLE

3B1

A G E

QUESTION I:

6	7	8	9	10	11	12	13
---	---	---	---	----	----	----	----

Suppose in a train accident, a man
lost one of his fingers/toes. If
this man has a child, how many
fingers/toes will he/she have?

RESPONSE:TOTAL

The child would have less number of fingers/toes.	11	1	11	11					7
The child will have normal fingers.	11	1	11	11111	11111	111	11111		23
I don't know.	1								1

FREQUENCY DISTRIBUTION TABLE

3BII

A G E

QUESTION II:

6	7	8	9	10	11	12	13
---	---	---	---	----	----	----	----

Suppose a man and his wife both lost their thumbs/finger in a train accident. If they have a child afterwards, how will this child be?

RESPONSE:

									TOTAL
The child will have less number of fingers or thumbs/short fingers.	0	11	11	11	111	11	1		12
The child will be normal.		111		11	1111	111	11	11111	19

FREQUENCY DISTRIBUTION TABLE

3BIII

A G E

QUESTION III:

Suppose another couple were injured
in a car accident in which they
lost their eyesight. If they have
a child afterwards, will he be
affected?

6 7 8 9 10 11 12 13

RESPONSE:

TOTAL

The child would be blind - partially or wholly.	0	11	1	11	1111	11	11		13
The child will be normal.		111		11	111	111	1	11111	17
I don't know.				1					1

FREQUENCY DISTRIBUTION TABLE

3BIV

A G E

QUESTION IV:

6 7 8 9 10 11 12 13

Suppose a small boy and a small girl
lost their fingers when they were just
babies. If they get married and have
a baby, will their baby be affected?

RESPONSE:

TOTAL

Yes, their baby will be affected.	0	11	11	11	1111	11	11	1	15
No, the baby would be normal.		111		11	11	111	1	111	14
I don't know					1			1	2

19 subjects are from the younger group. The remaining 14 are from the older group.

Those children who predicted that the child would be born with less number of fingers had various reasons for believing so. Some believe that as long as the mother is involved in the accident, the child will be affected. For some of them, it is only the mother who matters.

Hughie (8.6) "As long as it is the lady who is wounded, the child will show the scar, too."

For some others both parents have to have the deformity for it to be transmitted to the offspring. If it is only one parent who is affected, that is not sufficient to warrant transfer. For examples of these subjects see Susan (11.1) Table 3AV and Trevor (10.1) Table 3AIV. Yet there are a few scattered cases who believe that either the injury has to be really severe (Marla 10.11, Table 3AV) or has to involve internal organs (Gaelen 11.11, Table 3AVI) before it can be handed over to the offspring. On the other hand, some subjects couch their belief or explanation on a probabilistic framework. For example, Stephen (10.9) says:

If they had 3 children, 2 of the children could be like their father or their mother. They could have one or two fingers missing.

Thus, from this data one sees that the introduction of the female parent into the problem has had some impact on some subjects both from the younger and older group of subjects. They were lead into believing that the deformity could be inherited because the lady or both parents were involved in the accident.

Question III:

Suppose another couple were injured in a car accident in which they lost their eyesight. If they have a child afterwards, will he be affected?

This question was asked in order to find out whether the infliction of an injury to a very vital organ such as the eyes would make any difference in terms of whether the deformity would be transferred to the offspring or not. The question was developed from a picture of two wrecked cars which collided into each other.

Table 3BIII shows that 13 subjects claimed that the child born of the injured parents would be blind. Five of these 13 children are younger subjects while the remaining 8 come from the group of older subjects. Seventeen of the subjects said the child would be born quite normal. Of these 17 subjects, 5 are from the younger group while the remaining 12 are from the older group. One child said he did not know the answer.

By comparing the distribution of scores for Tables 3BII and 3BIII, one sees that the children maintained virtually the same responses for the two situations. (Please see Table 3AI to 3AVIII for Questions II and III). Apart from two subjects - Paula 10.2, Table 3AIV and Sergio 12.6, Table 3AVII who gave rather conflicting predictions for the two situations, every other one of the children from the two groups of subjects was consistent in terms of the prediction and explanation for the outcome of the phenomena. Thus, it could be safely said that the vitality of the injured organ does not seem to be considered a very important factor in determining the transfer or non-transfer of the deformity to the offspring.

Question IV:

Suppose a small boy and a small girl lost their fingers when they were just babies. If they get married (later) and have a baby, will their baby be affected?

In this question the effect of time lapsed or duration of a deformity on an individual was checked for in order to find out whether the subjects consider this an important variable for the determination of what an offspring can or cannot inherit from parents. The narrative and the question were developed from the picture of the two wrecked cars.

Table 3BIV shows that 15 children said that the baby will be born with short fingers like the parents. Of these 15 subjects, 6 are younger subjects while the remaining 9 come from the older group of subjects. Fourteen children claimed the injury to the finger of the parents would not affect their child in any way. Five of these 14 subjects are from the younger group and the other 9 subjects are from the older group. Two subjects said they do not know the answer to the question. One subject gave no response at all. Her score is recorded as zero.

Those children who said the injury could be transferred had explanations of the following kinds:

Sandra (12.8) "It is the difference of time. If one boy had it (the injury) before the other, the first boy, his son or daughter would have shorter fingers, the second boy his son would have longer fingers."

Sergio (12.6) "Because they haven't yet grown to all they can. They are still young. So it would affect their growing cycle."

Although these two cases exemplify the difficulties some of the children have regarding the understanding of inheritance, their explanations are

not as revealing as the one given by Michael (13.10) about how children think the mechanism of inheritance takes place.

E : Will the removal of these branches affect the seedling of this tree?

S : No. I don't think so.

E : Why do you say it won't?

S : It is with the seeds. When the seed falls, it starts its own life by itself. It starts building the tree. It makes its own branches. It does not, like a human, leave back traces from maybe the parents. I don't think a tree will.

E : If in this car accident a man lost his finger/toe, will this affect his child?

S : No.

E : Why not?

S : Well, it does not affect the child because the father is already mature. So when he goes to have children his brain would sense that he had a toe before. So I would guess it would not affect the child.

E : What about if the accident happened when this man was still a very small boy?

S : Well, I think it would affect the child, yea. Because the boy would not be mature yet. He would still be growing up. Because his brain would sense that one toe is missing, just having four. Yea, I guess so.

E : In the earlier explanations you gave me with regards to young plants, to young dogs, you said it would not affect them, why is it different now?

S : When I said about the dog, the dog was still small, it would get used to it. But a human is more developed. His own brain would know more about it than an animal whose brain is less developed. And the plant ---- well ---- (shakes his head and laughs).

Thus, one sees from the above excerpts that for some subjects the misconceptions about the phenomenon were not linked wholly to Time but rather to Time in its relation to the brain development of the organism in question. For this group of children, therefore, the genetic or inheritance phenomenon is directly under the jurisdiction (control) of the brain of the organism. Hence, plants do not have a brain, their own inheritance mechanism is bound to follow a different pattern to that of humans and animals.

Summary

The factors of 'sex of parent', 'time or duration of injury' were seen to have some effect on some of the subjects by misleading them to think that these are important factors to consider in terms of whether an injury-effect can be transferred or not. The misconception created by these variables was present in both the younger and older group of subjects. It was observed that the 'vitality of an organ' variable did not play any (important) role of changing the view of those subjects who already had what can be termed as acceptable concepts about the phenomenon. However, other subsidiary factors such as the severity of the injury and the location of the injured part were considered important by some subjects.

The explanations postulated by those subjects who said the child will be affected fall under two categories. There were those who invoked a purely somatic or organismic control mechanism. They mentioned organs such as the brain (Michael 13.10) and blood (Shannon 10.2) as responsible for the control of the phenomenon of inheritance. Some invoked a naturalistic control mechanism. These mentioned items such as the 'life cycle' as the determinants of inherited traits. Among this mislead group of subjects, some believe the mother plays a more important role than the father in the contribution of the inherited traits.

Those subjects who gave what could be called acceptable responses have resorted to examples of animals (domesticated), examples of relatives and friends' parents who have lost a body part in accidents and yet have normal offsprings, to defend their positions. For examples see Paula (10.2) Table 3AIV, Sarah (11.2) Table 3AVI and Tony (12.6) Table 3AVII.

It could be concluded from all these findings that the development of this concept in the subjects who were studied, does not seem to be relevant to a theory of naturally unfolding structures. Rather it is dependent on the various experiences to which the children have been exposed in the course of their everyday life.

TASK IV -

Statement:

Task IV and Task V are by their nature quite different from the previous three tasks. Unlike the phenomena tested for in the earlier 3 tasks, the phenomena of colour and height around which the following 2 tasks are developed are genuinely inherited characteristics in those animals to which they can be associated. The two tasks themselves are slightly different in that colour in dogs is a purely inherited characteristic while the height in man is both inherited and also affected by environmental influences. It is in an effort to know what beliefs children have for these two phenomena that the following tasks were presented.

TASK IV

This task was presented in stages in which other very important factors that should be considered by the subject before a logical prediction could be made, were systematically held back by the investigator. These variables were gradually introduced as the interview progressed.

Question I:

If a black (female) dog is to have puppies, what colour would the puppies be?

The children were presented with a coloured picture of a black female dog. No picture of a male partner was shown. Thus the factor of the father dog was withheld in order to find out whether the subjects would consider this as an important factor in the determination of the

colour of the puppies. Following this a picture of six uncoloured puppies was shown to the subjects. As mentioned in other sections, the responses of the subjects were made up of a predictive part and an explanatory part.

According to Table 4BI, 13 subjects predicted that the puppies would get a black colour. Of these 13 subjects, 9 are from the younger group (6-9 years), and 4 are from the older group (10-13 years). It is interesting to note that after the age of 9 years the number of subjects making this kind of prediction drops down sharply. For example, no subject in age 10, 11 and 12 made this type of prediction. In fact, all the 4 older subjects who said the puppies would be black are 13 year olds. The 4 come from the same school. However, one 11 year old subject said it is usually the father who gives the colour to the puppies and not the mother-dog.

Eighteen subjects predicted that the puppies would be a mixture of many colours depending on the colour of the father-dog and also the colour of the ancestor dogs from whom the parents were born. Among the 18 subjects who gave this type of prediction four were from the group of younger subjects. The remaining 14 are from the group of older subjects. It is interesting to note also that the number of subjects making this kind of prediction per age group increases markedly as from age 10 onwards with the exception of age 13 where most subjects opted for the mother colour.

Those subjects who said the puppies are going to be black advanced many different reasons to support their prediction. One of the most popular of these reasons is, "the puppies are going to be black because they take after their mother who gave birth to them".

Examples of these cases are Christina (5.6) Table 4AI, Sandra (7.6), Brenda (7.8), Hughie (8.6) all in Table 4AII, Kelly (13.7), Mike (13.10) both in Table 4AVII. The one subject who said that the puppies will take after their father's colour said that it is just the natural course of the process of inheritance. One sees that all of the subjects cited above have invoked a naturalistic explanation to support their claim.

Some other subjects who predicted that the puppies are going to be black argued that "they take after the colour of the mother because she takes care of them". See Jamie (7.4) Table 4AI. For this subject it is the amount of attention which a parent dog gives to the puppies which determines which colour the puppies would acquire. The less time a parent dog spends with the puppies, the fewer characteristics will the puppies acquire from that parent. This subject thus invokes an environmental explanation for his support.

There is again one subject who said that the colour of the parent dog does not matter at all. What matters to him is the specific "colour of the teats from which the puppies suck milk". If the teats are white, the puppies are going to be white regardless of the mother's colour. See Gary (10.1) Table 4AIII. In this case the subject is invoking an organismic (somatic) explanation for the origin of the colour of the puppies.

The above explanations of environmental, naturalistic and organismic (somatic) are not unique to the above subjects alone. Some of the subjects in the other group who by their prediction appeared to recognize the necessity of knowing the colour of the male partner and even the ancestors gave explanations that reveal their ignorance about the phenomenon. They too invoked environmental as well organismic

(somatic) explanations for their support. For example Tricia (7.5)

Table 4AI, said:

"I think they (puppies) would be either all black or black and white, not just white. They would get the white from the male dog or from the sun".

Tricia is partly invoking an environmental origin for the other colour on the puppies. She says this colour would arise from the sun. She may have been misled to believe that dogs become sun tanned, since this study was conducted in summer.

The example of a subject who invoked an organismic (somatic) explanation in this group is Richard 11.4, Table 4AVI. Richard said:

"The puppies would probably be black - most of them, I think probably have odd whitespecks. Because there might be something like that inside the body of the mother".

Thus Richard is invoking an organismic (somatic) origin for the other colours of the puppies. However, the majority of the subjects in this group of 18 subjects did not sidetrack in their statements at all. They were careful to note that there may be other colours emerging on the puppies but they have emphasized the necessity for them to know what the colour of the father is and in some cases even what the colour of the ancestor dogs are. So for these subjects knowing only the colour of the mother-dog is not sufficient enough to warrant a certainty prediction. For instances of these subjects see Trevor (10.1), Paula (10.2), Shannon (10.2) all in Table 4AIV; Stephen (10.9), Susan (11.1) both in Table 4AV; Sarah (11.2), Eric (11.10) both in Table 4AVI; Tony (12.6), Sergio (12.6), Sandra (12.8), Liza (13.5) all in Table 4AVIII. It is quite apparent from this data that although some younger subjects e.g. Douglas (8.1) Table 4AII invoked this hereditary explanation for the phenomenon, the majority of the subjects who advanced it come from the older group

especially from age 10 onwards.

Question II:

If a white male dog and a black female dog have six puppies.

What colour would their puppies be?

In this question the factor of the father dog which some of the subjects did not consider for the prediction in the last question was introduced. A picture of a white male dog was brought side by side with the black female dog.

It could be seen from Table 4BII that 19 of the subjects predicted that the puppies would either be black, white or a mixture of these two colours. These 19 subjects centred their thoughts only around the colours exhibited by the parents. They did not consider any recessive factors (from the ancestral line) which could have been present in the parent-dog's genetic make-up. Within this group of 19 subjects, subgroups are clearly evident. Thirteen of these 19 subjects said that only the two colours of the parent dogs would show on the puppies. Five other subjects claimed that the puppies would all be black after their mother. One subject said they would be all white after the colour of their father.

Of the above 19 subjects who centred their thoughts only on the colours exhibited by either one or the two parent dogs, 8 are from the younger group of subjects. Ten subjects are from the older group. The one subject who opted for the father is from the older group too.

There were 13 subjects who showed caution or rather scepticism and imprecision about their prediction. They claimed that the puppies could be black, white or a mixture of black and white and/or anything. These 13 subjects were not misled by the deceptive colours shown by the parents.

They believed there were other factors at work although some of them did not know what these factors were. Four of these group of 13 subjects are from the younger group. The remaining 9 are from the older group of subjects.

The explanations of the 19 subjects who have based their prediction only on the colour of the parents fall into 3 categories:- there are those who invoked a naturalistic explanation for the origin of the colours. Some of these subjects have failed to recognize any principle of dominance or recessiveness in the issue of inheritance. They have claimed that the puppies would be black and white with equal distribution. Those who have quoted figures have said 3 puppies would be black and 3 would be white after their mother and father. For example, Jun (10.6) says:

"I would say three of them would be black and three of them white. Three of these would be girl and the other three would be boy".

For more examples of this form of thinking see Marla (10.11) Table 4AV, Michael (9.2) Table 4AIII, Walter (13.8) Table 4AVIII. Within this group of 19 subjects also, there are those who said the puppies were going to be black regardless of the presence of a father with a different colour. For instances of this see Nancy (9.0) Table 4AIII, Tony (12.6) Table 4AVII. For this group of subjects it is only the mother who gives colour to the puppies since the puppies come from her body. Yet there are those who saw the father as the only important factor to consider. To them the mother does not matter. Examples are Liza (13.5) Table 4AVII and Gaelen (11.11) Table 4AVI. The above three different types of explanations for the origin of the puppies' colour are all naturalistic.

Quite a few subjects among the 19 invoked an environmental explanation for the phenomenon. Trevor (10.1) Table 4AIV says this about the situation:

"The puppies could be either colour, I guess. They could be a mixture or grey. Probably more would be black because black is a darker colour than white".

Trevor explains the inheritance of colour in the light of what he knows about paints. The darker the colour the more dominance it will show over the others. Gary (10.1) still invokes an organismic (somatic) explanation when he insists that "as long as the mother's teats are black (or white) that is the colour the puppies will be."

For the majority of the 13 subjects who predicted that the puppies could be black, white, mixed or anything, there is no indication that their explanations are buttressed by an understanding of the mechanism underlying the phenomenon. Some of these subjects confessed that they do not know how the other colour arises but they are aware it could appear on the puppies. Others have said that the many colours arise on the puppies because the mother mates with many different father-dogs before the litter of puppies is born. Yet a few members of this group of 13 subjects have shown a recognition of some form of randomness in the way the colours appear on the offspring. For example Shannon (10.2) says:

"Sometimes they are black, Sometimes they are mixed, and other times they take after the mother. Sometimes after the father".

Although it may not be quite apparent from her statement, one could see Shannon illustrating a rudimentary appreciation of an underlying principle of randomness (random assortment of genes) in the inheritance

FREQUENCY DISTRIBUTION TABLE
4BI

	A G E							
QUESTION I:	6	7	8	9	10	11	12	13
If a black dog (female) is to have puppies, what colour would the puppies be?								

RESPONSE:

TOTAL

Black	1	111	1	1111			1111	13
They get the colour from the father.						1		1
Mixed colour from mother and father/ancestors.		11	1	1	111111	1111	111	1
								8

FREQUENCY DISTRIBUTION TABLE

4BII

A G E

QUESTION:II:

6 7 8 9 10 11 12 13

If a white male dog and a black
female dog have six puppies.
What colour would their puppies be?

RESPONSE:

TOTAL

Black and white (or black and white mixed)	1	1		11	11	111		1111	13
They would be black.		11	1	1	1				5
They would be white						1			1
They would be black and white and/or anything.		11	1	1	1111	1	111	1	13

FREQUENCY DISTRIBUTION TABLE

4BIII

A G E

QUESTION III:

Which one of the parent dogs do
you think gives more colour to the
puppies

6 7 8 9 10 11 12 13

RESPONSE:

TOTAL

The mother gives more.	1111	11	11	111	1	111	111	18
The father gives more.					11		1	3
They both give equally.	1	1		1	1		1	5
The stronger of the two colours shows more				11				2
Sometimes the mother at other times the father.					111	1		4

FREQUENCY DISTRIBUTION TABLE

4B1V

A G E

QUESTION IV:

Can the puppies have any other
colour apart from the colour of
the parent dog?

6 7 8 9 10 11 12 13

RESPONSE:

TOTAL

No. They won't.		11	1	1				1	5
Yes. They could.	1	111	1	111	1111111	11111	111	1111	27

of colour. This random assortment of genes usually takes logical shape (in its phenotypic manifestation) only when large counts of offsprings are taken over a long period of time.

On the whole although many subjects from the younger and older group of subjects base their prediction only in terms of the colour of the parents, quite a number of subjects from these two groups do recognize other hidden variables which are very important for the making of a meaningful prediction. The imprecise predictions which manifest this awareness have been observed more noticeably at age 10 onwards for the subjects of this study.

Question III:

Which one of the parents do you think would give more colour to the puppies?

In order to find out what beliefs the children have regarding whether any one parent can be responsible for the giving or handing down of inherited characteristics to the offspring, the above question was presented to the subjects.

As is reported in Table 4BIII, 18 subjects claim that the mother usually gives the colour to the puppies since she is the one who gives birth to them. It would be interesting to hear some of their statements:-

Johnnie (7.4) "Dogs get their colour from their mother. They do not get a colour from the father because they weren't born from him".

Tony (12.6) "The mother because she is closer to them, because the father is not always there. The mother will always be till they get older. The majority will take after her because they came from her body".

Mike (13.10) "Maybe the mother because she has them in the womb.

The blood passes through them and their mother's body. So I guess the mother may contribute more".

As could be seen from the above segments this claim came from both the subjects of the younger group and the subjects of the older group. It could also be noted that Johnnie invoked a naturalistic explanation. Tony a partly environmental; and Mike invoked an organismic or somatic explanation for the transmission of colour in dogs. Of the 18 subjects who made the above claim 8 are from the younger group. The remaining 10 subjects are from the older group.

Three subjects claimed that the father usually gives colour to the puppies. All three are from the older group of subjects. They were not able to give any reason why they hold such belief. Examples are Richard (11.4) Table 4AVI, Gaelen (11.11) Table 4AVI, and Liza (13.5) Table 4AVII.

As in Question II, some subjects still insisted that both parent contribute equally. For them there is no question of one parent dominating the other. They have no belief in the dominance theory of inheritance. For example Christina (5.6) says:

"If there are six puppies, three would be white and three would be black".

The subjects who advanced the above equality or non-dominance theory are 7 in all. Five of them are from the younger group and 2 are from the older group of subjects.

The last group of subjects are those who made very imprecise predictions about the colour the puppies would have. To this effect Stephen (10.9) says:

"Sometimes it is the mother at other times it is the father".

A more illuminating statement in this respect is that made by Shannon (10.2) which has already been reported in the analysis of Question II. Three subjects made these type of imprecise predictions. All three of these subjects are from the older group of subjects. It is interesting again to note that this very cautious and imprecise statements appear only at age 10 among the 32 subjects who participated in this study.

Question IV:

Can the puppies have any other colour apart from the colour of the parent dogs?

(In this question the subjects were asked whether it is possible for the puppies to get any other colour different from that of their parents). This question was asked in order to be able to distinguish those subjects who were rigid and certain about their predictions from those who were flexible and think in terms of possibilities about their prediction.

As reported in Table 4BIV, 5 subjects claimed the puppies could not get some other colour other than that shown on their parents. Four of these subjects are from the younger group of subjects and 1 is from the older group. Twenty seven children predicted that it is very possible for the puppies to have a colour not exhibited on the fur of their parents. Of these 27 subjects 8 are from the younger group of subjects. The remaining 19 are from the older group. It is very interesting to note the accelerated increase in frequency of the subjects making this flexible form of prediction at age 10 onwards. In fact apart from one 13 year old no subject from the age of 10 onwards predicted that the puppies would not get another colour. Thus age 10 appears to be crucial in terms of the emergence of this flexible form of thinking for the 32 subjects who were studied.

The various explanations given by the subjects, for the origin of the other colours that may appear on the puppies' fur, fall into five different categories. There were those subjects who confessed that they did not know where these colours arise from but they were aware it is possible for the puppies to have other colours. Michael's (9.2) interview segment is presented to exemplify the group.

"They might be different colour from the mother and father. But I do not know where they will get this other colour from".

This ignorance was shown by both the younger and older group of subjects.

There were also those subjects who believe that the origin of the strange colour on the puppies was environmental. Tricia (7.5) mentioned the sun as responsible. Christina (5.6) mentioned water as the agent responsible for changing the colour of dogs. She said:

"Getting washed like it happened to my dog too. When we washed it, it had whitespots on its fur".

Richard (11.4) thinks it is the food the puppies eat which gives them the different colours. He says:

"Yes, maybe different kinds of foods".

Some other subjects believe the phenomenon is just a weird natural occurrence which has not yet been uncoded by man. To this effect Sergio (12.6) made this statement:

"Yes, it happened before. That is just nature. I don't think anybody knows. I don't think they have found that yet. It is just a weird thing".

Thus to some extent ^{he} is invoking a naturalistic explanation for the origin of this strange colour.

Yet Gary (10.1) invokes a somatic (organismic) explanation for the strange colour on the puppies. He says:

"If the teats are black, the puppies would be black".

Finally, there are those subjects who have invoked a hereditary explanation for the origin of the strange colour on the puppies. Two cases are presented to exemplify the group:

Sarah (11.2) "They would probably get brown. I am not sure where from.

Because you sometimes have characteristics that your parents did not have. It might be in the back - from the ancestors of those (parent) dogs".

Walter (13.8) "I suppose they could. From the breed of the parent dogs".

Although this form of explanation was found more among the older subjects it was not exclusive to them. Quite a few younger subjects exhibited the same form of thinking too. For Douglas (8.1) said"

"They may get goldy-black or brown from relatives - grandma and granddad".

However, on the whole the environmental naturalistic and somatic or organismic explanations for the origin of the strange colour on the puppies, were more popular explanations among the younger subjects than the older ones. While the hereditary explanation was favoured more in the group of older subjects than in the younger one.

Summary:

Three levels of abstraction have been demonstrated by the various responses which were given by the subjects. There were those subjects who regardless of the gradual introduction of other important factors by the investigator, could recognize only the mother (or father) as the sole giver of inherited characteristics. This subjects did not see beyond the mother (father) variable to make their predictions. To them the role of the other parent partner and the ancestral line are not

significant factors for the determination of what an offspring could inherit. Although this level of abstraction was present in both groups of subjects it was much more popular among the younger group of subjects.

There is a second level of abstraction. In this level the subjects recognized the two parents as important factors which work together to determine the offspring's characteristics. However, they did not see beyond the two parents. They failed to recognize the importance of the ancestral or hereditary line of the parent dogs. Their thoughts were absorbed solely by the colours exhibited by the father and the mother. Those subjects with these level of thinking are found in both groups - the younger and the older. It appears from Table 4BII that in fact the two groups seem to have about the same number of subjects exhibiting this form of thinking.

Then there is a third group who exhibited a third level of abstraction in which they recognized the parents as well as the ancestral line as significant factors to consider in order to make a meaningful prediction about the colour of the offspring. Hence the task as it is did not supply sufficient information that would warrant a precise prediction, these group of subjects only predicted in terms of possibilities. Although very few subjects in the younger group showed this form of thinking, it was seen more among the older subjects than the younger ones.

For the explanations which the subjects have used to substantiate their claims, four categories (of explanations) have emerged. These are the environmental, naturalistic, organismic (or somatic) and hereditary. The first three categories, i.e. the environmental, naturalistic, and organismic were explanations invoked more by subjects from the younger group than the older group at various points during the questioning. The

fourth category was seen more in the older group of subjects where it appeared more often after age 10.

Since the genotype of the dogs used for the task was not known, the various predictions given by the subjects cannot be said to be wrong or right. They can only be categorized in terms of levels of abstraction. It is hoped that with the use of these levels of abstraction we would be able to build up our understanding of children's belief patterns about the phenomenon of inheritance.

TASK V

Although the response of every subject to a question is supposed to have a predictive as well as an explanatory part, the analysis of the first two questions for this task deals only with the predictive aspect of the responses. Question III is dedicated wholly to the explanations advanced by the subjects for the predictions given for Question I and Question II. This has been done to avoid undue repetition.

Question I:

If a tall man and a short woman have a child.

If this child is a boy, how tall would he be when he is fully grown?

Table 5BI reports that 23 subjects predicted the child would be tall. These subjects claimed that since the child is a boy, he would look like his father. Of these 23 subjects 10 come from the younger group. The remaining 13 come from the group of older subjects. Two other subjects from the younger group said the child would be short when fully grown because, for them, children usually acquire the height of their mother.

Four subjects claimed the child would be of medium height since he is a blend between a short mother and a tall father. All four of these subjects are from the group of older subjects.

Finally, there is a group of subjects who said the child's height is a difficult phenomenon to predict precisely since he would come looking like the father or the mother or none in terms of height. For this group of subjects the answer is "it would depend on whom the child takes after". Three subjects made this claim. All three of these subjects come from the group of older subjects. This imprecise and probabilistic response was first seen at age 10 for the subjects who

participated.

Question II:

If the child (born of the short woman and tall man) is a girl: How tall will she be?

Table 5BVI shows that 21 children believe the child born of these contrasting parents will be short like her mother since she is a girl. Of these 21 subjects, 12 are from the younger group of subjects. The remaining 9 are from the older group. Three other subjects said the girl would be tall after her father since, for these 3 subjects, the father always contributes the height of the child while the mother contributes beauty features such as shape of nose, colour of eyes and hair. These 3 subjects are from the older group.

Yet three subjects, also from the older group said the child will be of medium height - a kind of non-dominance blend between the tall father and the short mother.

Finally, there is the fourth group of subjects who said, as in the previous question, that the height of the child will depend on whom she takes after. There are five subjects who made this claim. All five came from the group of older subjects. Again the first appearance of this flexible form of prediction for this concept was seen at age 10 among the 32 subjects.

Question III:

Why do you say so?

This question asked of the subjects to give reasons for the predictions they have made for Question I and Question II. As reported in Table 5BIII, 22 subjects had explanations, about the phenomenon of height inheritance, which were linked in one way or another to the parent's physical appearance,

FREQUENCY DISTRIBUTION TABLE

5BI

A G E

QUESTION I:

If a tall man and a short
woman have a child:
If this child is a boy, how
tall will he be when he is
fully grown?

6 7 8 9 10 11 12 13

RESPONSE:

TOTAL

The boy would be (very) tall.	1	11111	1	111	11111	111	111	11	23
He would be short.			1	1					2
He would be medium.					1	11		1	4
It depends on whom he takes after.					1		1	1	3

FREQUENCY DISTRIBUTION TABLE

5B11.

A G E

QUESTION 11:

6 7 8 9 10 11 12 13

If the child is a girl, how
tall will she be?

RESPONSE:

TOTAL

She would be short.	1	11111	11	1111	11111	1	1	11	21
She would be tall.					1	1	1		3
She would be medium.						11		1	3
It depends on whom she takes after.					1	1	11	1	5

FREQUENCY DISTRIBUTION TABLE
5BIII

A G E

QUESTION III:

6 7 8 9 10 11 12 13

Why is this so?

RESPONSE:

TOTAL

Because the boy takes after the father and the girls after her mother.	1	1111	1	111	11	1	11	14
Because the mother gives birth to the babies. The father only can give the height to a child.			1			1	11	4
Because the mother stays with the babies most times.				1				1
Girls are usually smaller than boys.					11		1	3
Because the child is a blend between the two heights of the parents.					1	111		4
Because the child will take after any of the two parents		1			1	1	1	5
I don't know.					1			1

FREQUENCY DISTRIBUTION TABLE

5BIV

A G E

QUESTION IV:

	6	7	8	9	10	11	12	13
--	---	---	---	---	----	----	----	----

Do you know of any other things
which could make a child grow tall?

RESPONSE:

TOTAL

No.	1	111	1	11	11	1	11	12
Yes, foods (exercise/sleep).	11	1	11	11111	1111	1	1111	13
Yes, ancestry.							1	1

or his/her role in the family as a whole. The various explanations of these subjects can be put into three categories as follows. There were those subjects who claimed: "The boy is going to be tall like his father because he is a boy and would look like him. The girl is going to grow short after her mother who is a short woman." To the group of subjects who made the above statements the issue of height inheritance in a sex-linked phenomenon. Examples are Johnnie (7.4), Jamie (7.4), Tricia (7.5) all in Table 5AI; Sandra (7.6), Brenda (7.8), Hughie (8.6) all in Table 5AII; Michael (9.2) Table 5AIII; Kenneth (9.10), Trevor (10.1) both in Table 5AIV; Jun (10.6) Table 5AV; Sergio (12.6), Sandra (12.8) both in Table 5AVII. There were those subjects who explained that the height, like any other characteristic a child inherits, is given only by the mother since she gives birth to the babies. Yet other subjects recognized the father as the only donor of certain specific inherited traits. They said that the height of a child is usually given by the father. But other features such as eyes or hair colour are contributed by the mother. For examples of this small group of subjects see Douglas (8.1) Table 5AII; Sylvia (9.5) Table 5AIII; Gaelen (11.11) Table 5AVI. The third group of subjects explained that "girls are usually smaller than boys", so they would expect the girl to be shorter than the boy e.g. Trevor (10.1) Table 5AIV; Kelly (13.7) Table 5AVIII.

Thus the 22 subjects, except for one, who made the above statements have invoked in one way or another a naturalistic explanation to substantiate their claim. The exempted one case invoked an environmental explanation when she said "because it is the mother who stays at home and cares for the baby", (Sylvia 9.5). Of these 22 subjects who gave the above explanations, 11 are from the younger group, the other 11 are from the

group of older subjects.

There is a group of 4 subjects who gave a non-dominance theory when they emphasized the blending aspect of the height between the mother and the father and predicted that the child will be medium. All four of these subjects are from the older group of subjects. Examples are Stephen (10.9) Table 5AV; Susan (11.1) Table 5AV also; Sarah (11.2) Table 5AVI.

Finally, 5 subjects said the child could take after the height of any one of the parents or could be in between. These subjects seem to recognize that many variables are involved and should be considered in order that a reasonable prediction could be made about the height the child would acquire. Hence, the information supplied by the investigator was not all that adequate, and the subjects could only give imprecise, cautious predictions and explanations. Four of these 5 subjects are from the older group and 1 isolated case from the younger group. One older subject said he does not know the answer.

Question IV:

Do you know of any other things which could make a child grow tall?

In this question the subjects were asked whether any other thing apart from what they have mentioned in their earlier explanations would aid the growth in height of the child. In the probing which followed, the investigator specifically tried to determine whether the subjects recognized food as an important substance which could aid growth in height.

As is reported in Table 5BIV, 12 subjects were not aware that foods do play an important role in terms of improving a child's height. Examples of these subjects are Christina (5.6), Jamie (7.4) both in Table 5AI; Stephen (10.9) Table 5AV; Richard (11.4) Table 5AVI. Of the 12

subjects who made the above claim, 7 are from the younger group of subjects and 5 are from the older group. Of the 7 younger subjects, two explained that what they believe helps a child to grow are the care and attention which a parent offers to the child, e.g. Tricia (7.5) Table 5AI; Sylvia (9.5) Table 5AIII.

Twenty subjects recognized food as an important factor to the development of a child. Some of these 20 subjects even mentioned other variables such as exercise, sleep, sometimes ancestry in the list of important considerations. Of these 20 subjects, 5 are from the younger group and 15 are from the older group. On Table 5BIV also, one could see the accelerated increase in frequency of subjects opting for this explanation at age 10 and after.

Summary

Three levels of abstractions could be discerned from the predictions given by the subjects. The first group of subjects are those who centered their attention only on one parent's characteristic to predict the height of the child. Some of them said a boy would acquire the height of the father and a girl the height of her mother. Others still within this group did not make this sex distinction. They explained that all children would take after the mother since the children come from her; or that all children take after the father's height, as women do not contribute height to a child. To these subjects women only contribute features which are related to beauty. Although these theories were advanced by subjects from both the older and younger group (of subjects), it was the majority of younger subjects who denied ^{strongly} that food and other environmental factors do not affect a child's height.

The second level of abstraction is that in which the subjects recognized both parents as playing a significant role in the question of height inheritance. The subjects, however, did not seem to recognize the underlying principle of randomness in inheritance or the dominance theory of inheritance. As a result they emphasized only the blending nature of the genes to produce a child of medium height. To these subjects, any time a tall and short parent would have a child that child would be medium in height. Those subjects who exhibited this form of abstraction are all from the older group.

Finally, there is the group with the third level of abstraction who not only recognized the heredity nature of the phenomenon in question but also recognized the fact that environmental factors do play a very important role in determining the outcome of a child with particular respect to height. In addition to hereditary explanations, these subjects mentioned sleep, exercise as factors which are important to the growth of a child. Apart from a few cases in the younger group, this type of abstraction was seen more in the majority of the older subjects with age ten becoming very noticeable in the various tables as either the point of emergence or the point for accelerated frequency for this theory.

The explanations advanced by the subjects to clarify their prediction fall into the following categories which have already been explained with exemplifying cases:- Naturalistic, Environmental, Heredity, and Heredity and Environment (together). The first two explanations were advanced by subjects from both groups - younger and older. But the second two explanations were mostly from the older subjects. One could also see from the tables how the age of 10 appears to be a dividing line in level of development of the heredity or heredity and environment explanations for the subjects interviewed.

Chapter 5

FINDINGS

This chapter gives an overall summary of the findings which are reported for Tasks I to Task V in Chapter 4. The summary itself is made up of three major sections. The first section deals with the findings relating to the beliefs the subjects have regarding the inheritance or non-inheritance, by offsprings, of deformities arising from environmental injuries. The second aspect deals with the beliefs relating to the phenomenon of the inheritance of colour in dogs and height in human beings. The third part summarizes the explanations advanced by the subjects in their effort to justify their claims.

SECTION I: DEFORMITIES

Tasks I, II and III were dedicated to finding out whether the subjects were able to make a distinction between purely environmental features and purely hereditary traits in living organisms. According to the findings in the analysis a large number of subjects were not able to make this distinction between environmental features and inherited traits. These subjects, coming both from the younger and older group of subjects, had the misconception that a deformity caused by an injury could be transmitted by a parent to the offspring. A number of subjects who in fact initially claimed that the feature cannot be inherited, changed their opinion when certain factors or circumstances (listed below) were introduced into the questions. With the introduction of these situations or factors, the subjects said the deformity could now be transferred to the offspring. The number of mislead subjects increased steadily from one question to the next. The circumstances or factors which seemed to be important for

the subjects were:

- (1) the elapse of time: Subjects often believed that if the parent suffered from the injury a long time ago, then there would be more chance for the resulting deformity to be transferred to the offspring. To this effect Jun (10.6) said "The puppies' tail would be short. If the dogs have a short tail for a long time, I think it will be in their system."
- (2) large numbers: Subjects often believed that when all members of a large populations of animals suffer the same injury, then the offsprings born of the deformed parents would acquire the deformity. The same subject Jun (10.6) would be cited as an example here. He said: "Their tails (puppies) would all be short I think. If you get used to seeing all of the dogs getting short tails, it would be kind of funny for other dogs to have long tails."
- (3) repeated injury: Subjects often had the belief that if an injury is inflicted on a species of animals repeatedly, from generation to generation, by repeated cutting of tails for instance, this would gradually lead to the breeding of dogs without tails. About this matter Vivian (13:0) said: "No, but if you keep on doing that (cutting the tails) long in time, it might - mutation, you know."
- (4) deformities in both parents: Subjects often believed that both the mother and the father have to have the deformity in order that the child could acquire it fully. If only one parent has the deformity then it would either not be transferred to the offspring or would only partially be transferred. For example Susan (11.1) says: "I think they would limp just a slight bit. The limping would come from their mother (who limps), the rest of their walking ways would

be from the father (who does not limp). They take after their mum and dad".

- (5) "Vitality of an organ": Subjects did not seem to recognize the factor of 'vitality of an organ' as important for the determination of which injured organ the offspring would inherit and which one he would not. In this question the eye was regarded a more important organ than the finger. For the subjects however, all organs - whether regarded as important or less important, are subject to the same "genetic" law. Any organ injured in the parent stands an equal chance of transferring the deformity to its relative organ in the offspring.

SECTION II: COLOUR AND HEIGHT

Whereas the inheritance of colour in dogs can be explained with purely genetic principles, the inheritance of height in man is influenced by both heredity and environment. The responses given by the subjects to the questions relating to these two phenomena can be categorized into 3 levels of abstraction.

- (1) In the first of these three levels, only one parent was recognized as the sole giver of inherited material to the offspring. The majority of the subjects with this level of abstraction recognized only the mother as the significant factor. The father's role was not important. Most of the subjects with this level of abstraction were from the younger group. An example of a subject's statement from this group follows: Sylvia (9.2): "The female dog contributes more colour to the puppies. Because she is the mother. The baby puppies come out of her body."

- (2) In the second level of abstraction the subjects recognized both parents as important contributors. However, the theory these subjects advanced was, as a whole, a non-dominance one where both parents contributed equally to the offspring's phenotypic characteristics. Subjects from both the younger and older group advanced this level of thinking. An example of a subject with this level of thinking is Susan (11.1). She said: "I think the boy and the girl will be in between (the mother and the father's height). Because they are both the mother and the father's babies, so they will take after them".
- (3) The third level of abstraction was where the subjects recognized a heredity (and environment) principle as the operating mechanism that determines which characteristics the offspring would inherit. This level of operation, which required imprecise and flexible responses, was found mostly among the subjects of the older group. An example of a subject with this form of thinking is Mike (13.10) when he said: "Sometimes too the girl will be like her father. The boy could be like his father but he could also be like his mother. It depends."

SECTION III: EXPLANATIONS

To every question from Task I to Task V a subject's response was supposed to have a predictive as well as an explanatory part. The explanations the subjects advanced to justify their predictions were many and different. These various explanations could be categorized into 4 groups.

- (1) Environmental: Some subjects invoked purely environmental explanations for the appearance of (inherited) traits in the offspring. Those subjects who invoked this kind of explanation mentioned things

such as the sun, water, food, care, mimicry as mechanisms which control the acquisition of inherited traits in living organisms.

- (2) Organismic or Somatic: There were those subjects who invoked organismic or somatic explanations for the origin of the inherited trait. In this group of subjects items such as nerves, brain, blood, teats, branches were named as the agents responsible for the transmission of inherited characteristics.
- (3) Naturalistic: There were other subjects who invoked a naturalistic explanation for the emergence of the traits on the offspring. This group mentioned life-cycle, nature, sex-resemblance to parent, motherhood, as the factors responsible for the determination of the offspring's characteristics.
- (4) Genetic principle: Finally there were those subjects who invoked a genetic principle either directly or indirectly for the development of an inherited trait in the offspring.

Although the Environmental, Naturalistic and Organismic forms of explanations were seen among some older subjects, the majority of the subjects who advanced these theories to justify their position were from the younger group. The group of younger subjects also exhibited very rigid forms of predicting; in that for them:

if the mother is injured, the offsprings would be deformed

if the mother dog is black, the puppies would be black

if the father is tall, the son would be tall also, etc.

For this group of subjects one independent variable explains one dependent variable. No other factor is brought into consideration. These younger subjects were also found to be unable to resort to techniques of making analogies and comparisons for elaborating or illustrating a point

in the discourse. They tended to explain each situation in its own entity without regard or relationship to what they had said previously. When conflicting statements were brought to their notice by the experimenter, they would usually fail to recognize the conflict. In circumstances where they recognized the conflict, they would clarify by saying that plants, animals and human beings are different organisms and therefore, are bound to have different genetic mechanisms. Because of this, things such as the maturity of the brain, blood, teats, branches were invoked by these subjects as the agents responsible for the control of inheritance in the respective organisms.

On the other hand the genetic theory was advanced mostly by children from the older group. The manifestation of this form of thinking among the subjects was exhibited in various ways. Some subjects mentioned items such as ancestral line, pure breeds, etc. to justify their imprecise and very probabilistic prediction about the outcome of the offspring. At the same time some of these subjects with these flexible patterns of thinking were observed to be able to make analogies and comparisons among familiar organisms and occasions to illustrate issues in the course of the interrogation.

CONCLUSION:

On the basis of these findings it could be concluded that for the 32 average ability subjects who were studied, the development of the concepts related to the inheritance of a deformity could not be based on a theory of naturally unfolding structures since both the misconception and the appropriate beliefs were found among the subjects from both the younger and older groups. The beliefs of the subjects were relative to the kinds of experience they have had with the phenomenon in question.

On the other hand the development of the probabilistic and combinatorial forms of thinking which are essential for the acquisition of the concepts related to the inheritance of colour in dogs and height in man, seemed to be consistent with a developmental theory of unfolding structures.

Younger children were found to be very rigid in their thinking while older children were flexible and recognized the necessity of knowing about many variables before appropriate precise predictions could be made. The age of 10 (ten years) among the subjects studied, seemed to be the dividing age where from many of the subjects develop the flexible form of reasoning which is a very essential quality for the capability to study genetics.

Chapter 6

DISCUSSION AND EDUCATIONAL IMPLICATIONS

In the previous chapter, the results of the study were presented in three sections. Section one dealt with the children's responses to the questions on environmentally induced deformities. Section two was a presentation of the results on colour in dogs and height in man. Section three was a summary of the explanations the subjects advanced to justify their various positions in section one and section two. The results appeared to indicate that children, of age 6 to 13 years have already formed their own theories to explain the various forms of phenotypic traits which they see exhibited by the various living organisms around them--man, animals, and plants. The theories which the subjects have advanced for the origin of the phenomenon of inheritance have ranged from environmental propositions, naturalistic propositions, organismic or somatic propositions to genetic propositions. The younger group of children i.e. 6 to 9 year olds were found more to advance the first three types of propositions or explanations. From what these subjects said, it was apparent that they did not have an understanding of the mechanism of inheritance. Nevertheless, these theories or explanations probably fulfill a psychological need in those subjects who advanced them.

Many educators would be tempted at this point to react that the subject matter of genetics is difficult for the age levels of the children who participated in this study, so the schools are justified in their policy of postponing the teaching of genetics till grade 10. It is on the basis of this argument which is not documented in the literature, that the elementary school science curriculum has flourished all these decades since Mendel's work of 1865, without

incorporating true aspects of genetics in the elementary science curriculum. The apparent neglect of this subject matter, however, does not prevent the mind of the children from working on the issue of inheritance. Their minds are constantly formulating whatever theory they can reasonably come up with to suit the circumstance at hand. It is in fact with respect to this neglected situation that Bernstein and Cowan (1975) in their study of young children's ideas of procreation, concluded with the following remarks:

Our results suggest strongly that children construct their notion (about babies); they do not wait to be told.....What is often taken as a misconception may largely be a product of their own assimilative process at work on materials with too complex a structure for them to understand.

These statements are in tune with the findings of this study. Whereas a lot of the environmental, organismic or somatic and naturalistic explanations came mostly from the subjects of the younger group, the wrong predictions however, came from all the age groups of children that were studied (6 to 13 years). Some of the misconceptions and the supportive theories of environmental, naturalistic and organismic origin are incredible and hard to envisage. What is even more unfortunate is the evidence shown in this study that some children of the older group still had these 'infantile' misconceptions. In other words for some of the subjects the misconceptions were found to fail to wear away with age. Therefore there is a likelihood that even when students are exposed to a formal study of genetics in school, these misconceptions may still persist in their minds. The B.C. Science Assessment (1978 Summary Report) reported that 30% of the subjects who were tested from grade 12 on the question of whether environmentally induced deformities could be inherited

predicted that these deformities would be inherited by the offsprings. For example, they were asked whether the offsprings of a mouse whose tail has been cut short would be born with a cut tail. Thirty percent of the grade 12 children of the schools that were tested in British Columbia chose a response which indicates the belief that the young mice would be born with short tails. The findings of that study become more surprising when one is reminded that grade 12 children in B.C. schools have had at least some amount of formal study of genetics.

However, scanning through the texts used for the grade 10 course in genetics in B.C. schools (a) Extending Science Concepts in the Laboratory by Manfred C. Schmid, which is the text used by most schools; and (b) Why You're You, by the Intermediate Science Curriculum Study, which is used by only 20% of the schools) reveals that the problem may not so much be with the children but it may rather be with the approach and materials which are used in the teaching of this course. Almost all of the lessons on genetics in those two texts are centred around fruit-flies and peapplants. None of the animals which are common and challenging to the children are used as examples. It could be speculated that this approach to the teaching of the subject (genetics) would possibly force some children to develop two cognitive structures relative to the topic of inheritance. It could be that these two cognitive structures develop separately and be quite unrelated to each other. First there could be one structure arising from the child's exposure to the formal study of genetics in school. Second, there could be another structure, potent but submerged below the former. This second structure would consist of all the beliefs the child has formed about the phenomenon of inheritance in the course of his informal learning. A child who finds himself in the

predicament where he cannot resolve the conflict between the two structures may never be able to develop an integrated picture about the phenomenon of inheritance; and so he/she may continue to invoke the wrong structure (of beliefs) in problematic situations related to inheritance.

Another problem which is created by centering introductory genetics lessons on fruitflies is the fact that many of the subjects regard the mechanism of inheritance to be controlled by the brain, the blood, the teats etc. Fruitflies have neither 'blood' nor do they have a mature brain as in man, nor teats as in dogs. So starting a course with an organism that has none of these items that confound a child's mind and at the same time form the basic structure for his/her understanding of the phenomenon, would not be a very promising venture; since it would mean picking up far above where the subject is. In this regard curriculum developers need to be guided by Ausubel's (1968) statements when he said:

If I had to reduce all of educational psychology to just one principle, I would say this: the most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly.

It would seem from the way the genetics courses for schools have been structured that the subjects' difficulties have not been taken into consideration in the planning of that curriculum. It appears that the structure of the course has been over emphasized to the detriment of a consideration of the child's real difficulties.

The finding of the fact that the younger children were rigid and non-probabilistic in their thoughts is neither unique nor is it strange. Other science educators have mentioned in earlier works about the fact

that young children take cognizance of only one variable in predicting the outcome of events. This pattern of thinking in which only one independent variable is held responsible for the outcome of the dependent variable is regarded by George Hein (1968) as 'particulate thinking'. In reporting on some activities elementary school children carried out on the Unit 'Rolling Objects', in which the subjects had to consider two or more variables to predict (appropriately) the outcome of the experiments George Hein (1968) made these observations:

These children do not have a statistical view of data and scientific observation.. Instead they have a particulate view. Each observation has its independent existence, each observation could decide the contest [outcome].

It is no wonder therefore that the younger subjects in this study were found to be rigid about their predictions and did not show evidence of being able to make analogies and comparisons as was the case with some children in the older group. In the light of this therefore it could be recommended that if a genetics course should be drawn up for average ability elementary school children, the course work for age 6 to 9 years should deal mainly with issues related to helping the children develop the ability to distinguish between purely environmental features and inherited traits in living organisms. Whereas simpler but truly genetic topics, that would require combinatorial patterns of thinking, the ability to make analogies and comparisons to arrive at precise or imprecise predictions, should be treated with children of the age of about 10 (years) and above. This course could also be directed towards helping the subjects realize the common genetic principles that operate in animals, humans and plants. An effort should be made to develop the course around living organisms that are familiar to the subjects in their

everyday encounter.

The above recommendations may raise many questions in the minds of readers. Questions such as: Is the investigator advocating a shift from fruitflies to something else? How can the children carry out activities without fruitflies? etc. would be asked. The answers to these kinds of questions again derive support from the findings in this study: Yes, for Elementary school grades especially, it is suggested that fruitflies should be put away temporarily until later in the child's life when activities with fruitflies could easily be related to other organisms around. It is thus recommended that the genetics course for elementary schools should be centred around larger animals, especially domesticated ones, to which the child relates more often in his everyday activities. In addition to the reasons already given for the recommended temporary dissociation from the study of fruitflies is the fact that even though these organisms are the best known for activity oriented lessons because of the simple traits they carry and the very fast rate at which they reproduce, handling them would entail many problems for the elementary school child. Amongst these problems are:

- (1) the fact that fruitflies are too tiny and delicate to be handled (without being damaged) by elementary school children.
- (2) the fact that the mechanism of anaesthetizing these organisms is too complex for elementary school children to carry out effectively with understanding.
- (3) the fact that ether, the chemical used for anaesthetizing the fruitflies is too dangerous to be entrusted to elementary school children.

Because of these difficulties and the finding that fruitflies themselves are not related to the problems the child is confronted with, this study would recommend for a teaching approach the use of appropriate slides of larger animals, film strips, pictures, and student and teacher lead discussions as effective alternative methods by which the child could be taught genetics in elementary school. This approach appears to be better than one that resorts to activities which have no bearing on the everyday problems of the child. Implied is that activities are not the only answer to all the learning difficulties children have as some educators seem to believe. Activities are good if they are related to the problems of the learner. In circumstances where the learning activity is not related to the child's everyday problem, then other methods of teaching which are more appropriate to the situation could be adopted and found to be far more effective. One of these situations where this approach is deemed appropriate is in the study of genetics in elementary schools.

Summary

The subjects of this study have demonstrated that the acquisition of concepts related to the inheritance or non inheritance of traits in living organisms follows two patterns. The acquisition of beliefs relating to deformities is purely a function of the experiences the child has had with the phenomenon in his everyday activities and encounters; whereas the beliefs related to the inheritance of colour in dogs and height in man are a function of the child's intellectual development (with age). For the 32 average ability subjects who participated in the study, the age of 10 (years) was found to be the dividing line for the acquisition of the flexible patterns of thinking. Below the age of 10 years the children were found to be rigid in their

predictions because they consider only one variable for the determination of the offspring's characteristics. At about the age of 10 and above the subjects acquire flexible and combinatorial patterns of thinking in predicting the outcome of the offspring's characteristics. On the basis of this findings this study recommends that elementary schools should take upon themselves the responsibility to tutor children of age 6 to 9 years about the non-inheritance nature of environmentally induced deformities in living organisms. This topic has been suggested for this age group since it is far simpler than true genetic topics which require combinatorial patterns of thinking. The children of the age of about 10 years and above who showed the ability to handle situations that required combinatorial patterns of thinking could be exposed to a pure but simple genetics course that is built around organisms which are more familiar to them.

RECOMMENDATIONS FOR FURTHER STUDIES

From the standpoint of the problem that was investigated and the methods adopted for that purpose, it becomes apparent that many recommendations for further research in the area of children's concepts about inherited characteristics could be made. These recommendations are:

- (1) Since this study only looked into the beliefs of children of average ability, educational implications of the findings could only be restricted to the group of children. Further studies of this type could be carried out on children of above average ability and below average ability in order to find out what their own beliefs are about the phenomenon of inheritance.
- (2) In the light of the findings of this study group instruments (for example paper and pencil questionnaire) could be developed and tested on whole classes or classes of average ability children to find out how prevalent the beliefs are among the children of the various classes. The findings could be used to recommend curriculum for the specific classes.
- (3) Another approach which could be employed in the execution of this kind of research is the adoption of statistical methods to collect the sample of children (of various abilities) and find out what beliefs this heterogeneous sample of children hold about the phenomenon of inheritance. The educational implications of the findings of such a study could be very important in today's schools since most schools have children of various abilities working together in the same classroom.

- (4) More controlled experimental investigations should be planned. The analysis method adopted for such studies should check out clearly whether factors such as sex, socio-economic level of home, do really influence the development of the beliefs that were investigated. However, within the strengths of the method adopted for this study, these two factors - sex and socio-economic level, were not found to be important in influencing the beliefs of the average ability children that were studied. Both boys and girls, children of low and high income residential areas, had successes as well as difficulties with the tasks. More careful studies are needed in this area, however.
- (5) This study only looked at two belief areas of the topic in question i.e. the area of environmentally induced deformities and the area of colour and height inheritance in animals and human beings respectively. Similar exploratory studies could be conducted on other areas of the topic of inheritance, for example sex-linked characteristics such as baldness, features such as the sixth finger etc. which deceptively appear randomly in the population could be investigated to find out what beliefs children hold about them.
- (6) An opinion questionnaire could be developed and handed out to Elementary School Science teachers to find out what their own opinions are about the introduction of a subject like Genetics (as is deemed appropriate for the children) in the Elementary school. Do they see any need for this in today's schools?

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APPENDIX I

Department of Science Education
Faculty of Graduate Studies
University of British Columbia
Vancouver, B.C.

May 16, 1978

Dear Parent:

Your child _____ has an opportunity to participate in a study directed towards understanding children's ideas about inherited characteristics. The study will take the form of a taped discussion of about 20-30 minutes between your child and the investigator on the subject of inheritance in plants, in animals and in man. (Your child will not be asked questions relating him or his family).

Could you kindly let me know by:

- (a) checking the appropriate space provided and
- (b) signing your name below

whether you would approve of your child taking part in this study.

Please return the signed slip in the envelope provided and send it to the school with your child.

I would appreciate your prompt response to this proposal.

Thank you,

Dennis Kargbo

_____ Yes, I would approve of my child taking part in this study.

_____ No, I would not approve of my child taking part in this study.

Signature

APPENDIX II
QUESTION-RESPONSE TABLE

Grade I

QUESTION-RESPONSE TABLE

IAI

			QUESTION I	QUESTION II	QUESTION III
			Suppose the leg of a female dog was broken by a motorcar. If this dog limps after it has become well. Would the puppies of the dog be born with a lame leg?	If two dogs (male and female) had their tails cut short in an accident, if they have puppies, how will these puppies be in terms of tail length?	If two dogs lost their tails while they were pups, if they have puppies when they are fully grown. How will their own pups be?
NAME	AGE	TOPIC			
Christina	5.6	Injuries on dogs.	They wouldn't have a broken leg. I don't know why.	I don't know. My dog has a short tail, but it is a boy. Of course boy dogs don't have puppies.	I don't know.
Johnnie	7.4		They might limp. Because the mother broke her bone, and leg, they might start to limp too.	They will have a tail. The car ran over the dog's tail, it did not run over the tails of their babies.	They would have full tails (implied).
Jamie	7.4		I say they maybe limping-might be not all the time, just sometimes--because em, they grow up inside the mother's tummy--I don't know the rest.	They will have a tail. The tail was ran over by a car, the pups will still have a tail.	They will not have a tail.
Tricia	7.5		I don't think the puppies will have a broken leg---because the pups are a different part of the mother. Just like if the leg is broken, the arm isn't broken.	I think that their puppies will have a tail. Because it is not them that got ran over.	They won't be affected.

Grade I

QUESTION-RESPONSE TABLE

IAI (cont'd.)

QUESTION IV

If the tails of all dogs in Vancouver
were cut short by their owners, what
will their new born puppies look like?
Why?

COMMENTS

They won't have a tail. I don't
know.

Christie is mislead to believe that
when large numbers of dogs suffer an
injury, then there is a great chance
that this will be transmitted to the
offsprings.

They will have a tail. Because
they didn't chop off their tails.

Johnnie's second answer appears to
contradict his earlier logic and answer
to the first question. When he was
further probed about the matter, he
explained the transmission of the broken
leg in terms of mimicking that the pups
would not necessarily have a broken bone
but will just walk like their mother.

I don't know.

Jamie believes the pups will limp a little
because they grow up in the mum's tummy.
But he does not believe the short tail can
be transmitted to the offsprings. He
explained the difference in transmission
to be caused by the fact that these are
different accidents. When he was reminded
about the contradictions he said he is not
aware he is changing his view - but he
thinks he is quite right.

They will be with a tail (and
then have their tails cut off)

Tricia believes that injuries are only inflicted
on people and they cannot be transmitted to the
offspring.

GRADE II

QUESTION-RESPONSE TABLE
1AII

NAME	AGE	TOPIC	QUESTION I	QUESTION II	QUESTION III
			Suppose the leg of a female dog was broken by a motorcar. If this dog limps after it has become well. Would the puppies of the dog be born with a lame leg?	If two dogs (male and female) had their tails cut short in an accident, if they have puppies, how would their puppies be in terms of tail length?	If two dogs lost their tails while they were pups, if they have puppies when they are fully grown. How will their own puppies be?
Sandra	7.6	Injuries on dogs.	The puppies might be a bit wounded. Because their mother is a bit wounded.	The puppies won't have tails because their mother and father don't have tails.	They won't have tails (implied).
Brenda	7.8		They would limp. Because the mother had a broken leg.	Their puppies won't have any tails. Because the mother and father did not have a tail.	They won't have tails (implied).
Douglas	8.1		They probably will limp - like if the mother is sick the babies will be sick. Whatever the mother is the babies will be.	Then the babies would probably have no tails. Because the mother has had problems, and probably the babies get the problems.	They won't have tails (implied).
Hughie	8.6		They would be black like she is with the wound-m-like--with a little scar on their leg. They would not limp like their mother anyway because it happened to her and not to them. No, they would not have a scar.	Their puppies will not have a tail. Because their mother did not have a tail.	The puppies won't have a tail.

Grade II

QUESTION-RESPONSE TABLE

IAII (cont'd.)

QUESTION IV

If the tails of all dogs in Vancouver
were cut short by their owners, what
will their new born puppies look like?
Why?

COMMENTS

They won't have tails (implied).	Even though Sandra claims she has many small animals at home to look after - dog, cat, mice, yet Sandra believes that the wounded dog can transfer the limp to her puppies. Sandra is of the opinion that even the short tail would be transferred to the puppies by their parents.
They won't have tails (implied).	It is quite evident that Brenda is of the opinion that whatever injury is inflicted on the parent animal, this would be handed down to the offspring's genetic code.
They won't have tails (implied).	Douglas believes that whatever problem the mother has this would be given down to the baby. He says you catch sickness from other people and like that a baby catches problems from its mother.
The puppies won't have a tail (implied).	When the apparent contradiction was brought to Hughie's notice with regards to his differential explanations for the two injuries, he repeated only his stance in what he had earlier said but was not able to elaborate.

Grade III

QUESTION-RESPONSE TABLE
IAIII

NAME	AGE	TOPIC	QUESTION I	QUESTION II	QUESTION III
			Suppose the leg of a female dog was broken by a motorcar. If this dog limps after it has become well. Would the puppies of this dog be born with a lame leg?	If two dogs (male and female) have their tails cut short in an accident. If they have puppies afterwards, how would these puppies be in terms of tail length?	If two dogs (male and female) lost their tails while they were puppies, if they have puppies when they are fully grown, how will their own puppies be?
Nancy	9.00	Injuries on dogs.	The puppies will not have a broken leg. The mother did not have the baby yet.	The puppies will have a tail. Because the mother's tail only got cut off.	They will have tails.
Michael	9.2		Some of them would limp because the mother was hurt before they were born.	The tails of the puppies might be short too. Because their father was in the accident and so a short tail might be transferred to them.	They will have a short tail (implied).
Sylvia	9.5		Normal. Because they are new puppies. Because nothing happened to them.	They will have a tail. Because nothing happened to them.	The puppies will have a tail (implied).
Gary	10.1		No, they won't limp. Because they are inside the mother's body and her body was not broken, it was the leg which was broken.	I think the puppy will have a tail. Because the mother used to have a tail, right?	The puppies will have a tail. Because these puppies had tails when they were babies.

GRADE III

QUESTION-RESPONSE TABLE

IAIII (cont'd.)

QUESTION IV

If the tails of all dogs in Vancouver
were cut short by their owners, what
will their new born puppies look like?

COMMENTS

They will have a tail. Because their mothers has their tails cut off.	Nancy was able to recognize that hurting the mother dog/s at any time in her/their lives will not affect their own puppies in any way.
They will have a short tail (implied).	Mike believes that once the mother or father suffered an injury before the babies (puppies) were born, there is a great chance that the phenomenon would be transferred to the babies.
The puppies will have a tail (implied).	Sylvia realizes that once nothing happened to the puppies while they are inside the belly of their mother, they're going to be born quite normal.
Their puppies won't have a tail. They will have a tail because their mother used to have tails.	Gary is first deceived by the large numbers but he changed his view as the questioning progressed.

Grade IV

QUESTION-RESPONSE TABLE
IAIV

NAME	AGE	TOPIC	QUESTION I	QUESTION II	QUESTION III
			Suppose the leg of a female dog was broken by a motorcar. If this dog limps after it has become well. Would the puppies of this dog be born with a lame leg?	If two dogs (male and female) have their tails cut short in an accident. If they have puppies afterwards, how would these puppies be in terms of tail length?	If two dogs (male and female) lost their tails while they were puppies, if they have puppies when they are fully grown, how will their own puppies be?
Kenneth	9.10	Injuries on dogs.	They might limp too. Because the mother had an accident before and she was limping.	They might have a very short tail or might have no tail.	They would have a short tail (implied).
Trevor	10.1		I don't think they'd limp, but their foot maybe a little different, like it might have a scar or something.	I don't think they would have a tail. They come out like their mother and father - probably. They won't have a tail.	They would not have a tail (implied).
Paula	10.2		I don't think it would affect them. I have a dog whose mother's leg was broken in an accident. This mother dog limps, but my own dog did not limp.	I don't think that would affect them either. Like grandma said they cut off the tails of the dogs when they are special breed. So I don't think it will affect the puppies.	I don't think it would affect the puppies.
Shannon	10.2		I guess some of the puppies might have a leg like that (lame) but it depends on the father too. I saw a show of a lady without arms but her own baby had arms; this could have been because of the father.	I wouldn't think that they would have tails, but I am not too sure. They take after their parents.	The puppies would have a short tail.

Grade IV

QUESTION-RESPONSE TABLE

1AIV (cont'd.)

QUESTION IV

If the tails of all dogs in Vancouver were cut short by their owners, what will their newborn puppies look like?

COMMENTS

The puppies would probably not have a tail.

Kenneth is of the belief that making an injury on a dog can be transmitted to pups. He believes that progressive cutting of the tail, generation after generation would gradually shorten it in the puppies.

I don't think so. They would probably come out like their mother and father (without tails).

Although Trevor does not believe that the broken bone in the leg would be transferred to the pups, he is convinced that a scar would appear on the pups. On the issue of the cut tail, he says this would be handed down to the puppies from the parents.

You would probably have to go round cutting the puppies' tail too. I don't think it would affect them - really, but if you go on and on - yes.

Although Paula resorts to explaining the non transfer of injuries from experiences, she however was lead to believe that successive cutting of the dog's tail from generation to generation would shorten the tail of newborns.

They would have a short tail (implied).

Shannon explained about the woman in the film who had no arms but had a baby with arms, so she believes the child must have taken from the father.

Grade V

QUESTION-RESPONSE TABLE

LAV

NAME	AGE	TOPIC	QUESTION I	QUESTION II	QUESTION III
			If the leg of a dog (female) was broken in a motorcar accident. Then the dog limps after she has become well. If she is to have puppies afterwards, will they be born with a lame leg?	If a male dog and a female dog were involved in an accident in which they lost their tails (both). If these two dogs have puppies, how will their tail length be?	If two dogs (male and female) had their tails cut short when they were still puppies. If they have puppies when they are fully grown, will their puppies be affected?
Jun	10.6	Injuries on dogs.	I don't think they would limp. Because the puppies are in the dog's stomach. They are no where in the dog's leg.	I think it (the tail) will be right in the middle. Their father and mother have short tails, they will be about in the middle. Not long enough - short.	The puppies' tail would be short. If the dogs have a short tail for a long time I think it will be in their system.
Stephen	10.9		It really depends. If its father has something wrong with it. It could affect the puppies in the tail or leg or ear.	Some would have tails but just stubby (short) tails. Others would have no tails.	They could have short tails or they would have no tails if they are not so lucky. So if their parents have no tail, they could end up not having ears.
Marla	10.11		Some might have a limp. Because it happened to the mother.	If they have six puppies, I would say some will come with short tails, others with medium. Because they used to have long tails, some might be medium.	Probably the puppies would have short tails. Because the tails have been short since they were small until they grow up. The mother has had it for a long time.
Susan	11.1		I think they would limp just a slight little bit. The limping would come from their mother, the rest of their walking ways would be from the father. They take after their mum and dad.	I think the puppies would be born with a short tail. Because their mother and father had just a little stump. If it is the one parent who has the short tail, the puppies would have a medium tail.	Their puppies would have a short tail.

Grade V

QUESTION-RESPONSE TABLE

1AV (cont'd.)

QUESTION IV

Suppose the tails of all the dogs in Vancouver were cut short by their owners, what will the newborn puppies look like in terms of tail length?

COMMENTS

The tails would all be short I think. If you get used to all of the dogs getting short tails it will be kind of funny for other dogs to have long tails.

A lot of them could have short tails but one or two could have long tails.

Some puppies would come with a short tail, some with a medium.

The pups would have a short tail.

Although Jun does not believe that the limp can be handed down to the puppies, he however believes that the cutting of the tail will be handed down in progressive stages. As the tail is cut from one generation to another, so it becomes shorter and shorter.

To Stephen the fact that a mother dog's tail is cut does not mean all pups will lose their tail, some would acquire this feature by losing the ears, by losing all or only part of the tail, etc.

The duration of the injuries is for Marla a very significant factor for transmission to the puppies. The longer it has been on the mother, the better the chances.

For Susan if only one parent suffered the injury, then only an in between (medium) characteristic will be given to the child. Both parents have to be injured for the injury to be transferred wholly to the child.

Grade VI

QUESTION-RESPONSE TABLE

LAVI

NAME	AGE	TOPIC	QUESTION I	QUESTION II	QUESTION III
			Suppose the leg of a dog (female) was broken in a motorcar accident. Then this dog limps after she has become well. If she is to have puppies afterwards, will they be born with a lame leg?	If a male dog and a female dog were involved in an accident in which they lost their tails (both). If these two dogs have puppies, how long will the tails of the puppies be?	Suppose two dogs (male and female) had their tails cut short when they were still puppies. If they are to have puppies when they are fully grown, how will these puppies' tails be?
Sarah	11.2	Injuries on dogs.	I don't think this defect can be transferred. Because it happened to her leg and not her inside.	The puppies would probably have a long tail. The dogs did not start off with a short tail in the breed so the puppies would have long tails.	The puppies will not be affected because it happened a long time ago. If it happened a short while ago it might have an indirect effect because the mother dog will be attending to her wound and not caring for the puppies, so they grow up unhealthy.
Richard	11.4		The puppies would just be normal puppies. They would not limp or anything wrong with their leg.	I would say they would just be normal puppies with just normal tails. Just because the tail is cut off wouldn't mean that much effect when it has birth.	Their puppies would be normal puppies. Just because you cut off the tail it wouldn't make that much difference.
Eric	11.10		Normal. Well, well leg has not get anything to do with it.	Well some of them might just have short tails or no tails. But none of them would have wrecked legs.	The puppies would have a short tail (implied).
Gaelen	11.11		They would be normal. It does not affect the puppies.	They would have a tail. Puppies grow in a such of a package (enclosure) and they are not affected.	The puppies would have still a tail.

Grade VI

QUESTION-RESPONSE TABLE

IAVI (cont'd.)

QUESTION IV

Suppose the tails of all dogs in Vancouver were cut short by their owners, what will the newborn puppies look like in terms of tail length?

COMMENTS

Their puppies would have long tails. But if you did this (cutting) for a couple of generations then the puppies would probably start getting shorter and shorter tails.

The puppies would not be affected (implied).

They probably would not have tails. Well the kids are mostly like their parents, so if their parents have no tails, then they gonna have no tails.

They would have a tail because it is only a physical (bodily) injury.

To Sarah the original characteristics of the breed determine what the pups would look like. An injury deformity would not be transferred.

Richard realizes that a deformity on the mother does not at all affect the young ones in any way. The limp or the cut tail will not be transferred.

When the contradiction in the responses was brought to Eric's notice he says he does not know why that difference exists.

Gaelen is not at all deceived to believe that any form of the injury can be transferred to the puppies from the parents.

Grade VII

QUESTION-RESPONSE TABLE

LAVII

NAME	AGE	TOPIC	QUESTION I	QUESTION II	QUESTION III
			Suppose the leg of a dog (female) was broken in a motorcar accident. Then this dog limps after she has become well. If she has puppies afterwards, will they be born with a lame leg?	If a male dog and a female dog were involved in an accident in which they lost their tails. If these dogs have puppies, how long will the tails of the puppies be?	Suppose two dogs (female and male) had their tails cut short when they were still puppies. If they are to have puppies when they are fully grown, how will their tails be?
Tony	12.6		The puppies will be O.K. It is not like the colour transfer. When a bone is broken, it is not transferred to the puppies.	Normal - because it is the same thing as a broken leg.	Their puppies would be normal.
Sergio	12.6		There is a chance that they might grow up with a limp and they might not be normal---most dogs---because of their mother; or else they could be just as normal as other dogs.	They could end up having no tail. Because the parents did not have any. So they would be born without a tail.	The puppies would have no tails (implied).
Sandra	12.8		The puppies will have the leg that she broke, or maybe a shorter leg or may walk with a limp.	They would have shorter tails. Because both parents had their tails broken off.	The puppies would come with a short tail.
Liza	13.5		I think they will be O.K.	They will come out O.K. I don't think the tail makes any difference.	The puppies would come out O.K.

Grade VII

QUESTION-RESPONSE TABLE

LAVII (cont'd.)

QUESTION IV

Suppose the tails of all dogs in Vancouver were cut short by their owners. What will their newborn puppies look like in terms of tail length?

COMMENTS

The puppies would be O.K.

Tony is convinced that injuries would not be transferred to the young; they are not like fur colours which could be handed down by the parents to their young.

The puppies would be without tails. Pretty sure about that since all the dogs in Vancouver did not have any tails, their pups would not; forever and ever no dogs would have any tails.

Sergio explained that since their mother limped; if there were six pups, 3 would limp and 3 would be normal. He says if the mother and father dog did not have tails, 5 of the pups would probably be without tails too when they are born. Sergio is deceived by large numbers too.

The puppies would have shorter tails than they are supposed to have.

Sandra is of the conviction that the puppies would come out like their parents - with wounded legs or short tails.

Their puppies will be with short tails, if all of them are like that and their environment is like that, so I think it wouldn't be. We are supposed to be born of the monkey and we only have a tail bone now.

Liza is deceived to feel that numbers make a great difference to the outcome of experimental results. And also that the progressive cutting of the tail of the dogs will shorten its length in offsprings gradually hence she cites the development of human beings from monkeys as examples.

Grade VIII

QUESTION-RESPONSE TABLE

1AVIII

NAME	AGE	TOPIC	QUESTION I	QUESTION II	QUESTION III
			Suppose the leg of a dog (female) was broken in a motorcar accident. Then this dog limps after she has become well. If she has puppies afterwards, will they be born with a lame leg?	If a male dog and a female dog were involved in an accident in which they lost their tails. If these dogs have puppies, how long will the tails of the puppies be?	Suppose two dogs (male and female) had their tails cut short when they were still puppies. If they are to have puppies when they are fully grown, how will their tails be?
Vivian	13.00	Injuries on dogs.	No, it would not affect the puppies. It has nothing to do with the puppies.	Well, the tails will be O.K. It does not have anything to do with it. It is a part of the mother and not the puppy that does not have the tail.	It will not affect the puppies.
Kelly	13.7		They would be normal. Any broken bone does not go to the babies. It does not have anything to do with it.	I think they would probably be O.K.	I don't think the puppies will be affected for the same reason I gave earlier.
Walter	13.8		I think they would be normal. The broken leg was not natural; it happened by car.	I think that the puppies should have a tail, because again it did not happen naturally.	Yes, it would have effect, because they were small when it happened to them. So they would inherit the tail as they grow up.
Mike	13.10		I don't think it would affect the puppies. They would not have a broken leg like their mother.	No, I don't think their tails will be short. Because my uncle breeds hunting dogs and he cuts off their tails. When these dogs have pups he has to cut off their tails, too. So I don't think it has anything to do with it.	No, I don't think it would affect the puppies.

Grade VIII

QUESTION-RESPONSE TABLE

IAVIII (cont'd.)

QUESTION IV

Suppose the tails of all dogs in Vancouver were cut short by their owners, what will their newborn puppies look like in terms of tail length?

COMMENTS

No, but if they keep on doing that long in time it might - mutation - you know.

Although Vivian's answers are right, her elaboration on long time cutting is wrong. She believes that the sequential cutting of tails from generation to generation will lead to mutational shortening of the tail.

The puppies will have tails.

Kelly is quite clear on the issue of accidents, injuries and inheritance.

No, this won't affect the puppies at all.

Although Walter is not deceived by large numbers, he is however deceived to think that the earlier a dog suffers an injury, the more the injury stands to be inbuilt in the dog's body and hence hand it down to its own puppies.

I don't think the puppies coming after them would have tails. The cutting of the tail will affect the nutrition, the nervous system. So it will change their reaction or something.

Mike is deceived by large numbers.

Grade I

QUESTION-RESPONSE TABLE
2A1

NAME	AGE	TOPIC	QUESTION I	QUESTION II	QUESTION III
			If a deep cut is made on the bark of a tree (e.g. rubber tree). Will the tree grow a scar?	If a tree is wounded and it heals its wound, would the scar formed be transferred to the offspring of this tree?	Suppose a tree has 20 branches and 10 of these branches were chopped off. Will the scars of these chopped off branches show on the young seedlings?
Christina	5.6	Injuries on trees.	No. I don't know why.	The tree will not heal its wound.	-----
Johnnie	7.4		Yes, sometimes it has a half scar.	No. Because they skinned the other tree but did not skin the little plant.	Maybe it could have those (scars).
Jamie	7.4		No, I don't believe plants can grow a scar---they are not human beings.	-----	I would say yes - No, it would not affect it.
Tricia	7.5		Yes, the tree can grow a scar.	The scar will not be transferred to the seedling. It is not the same tree because it hasn't got chopped off yet.	The scars will not be shown on the seedling. No, because it is a different tree again.

Grade I

QUESTION-RESPONSE TABLE

2AI (cont'd.)

QUESTION IV

If the leaves of a tree were cut in two halves (demonstrate with leaf) when the tree was still a seedling plant, will this affect the shape of the seedling leaves of this tree?

COMMENTS

Christina complained she was tired. After the rest period, the subject became disinterested in the interview and did not co-operate any more.

I don't know.

When the apparent contradiction of the statements was brought to Johnnie's notice, he said he does not know why the difference is so, but he is convinced about his own answer. On further probings, he appeared to be confused and just gave up by saying "I don't know".

Jamie was not convinced even when the experimenter explained that trees can grow scars, she says that there is only one thing he believes that human beings and plants do in common. That is that they both drink water. When the subject was asked why he is constantly changing his views, he denied that, he was not changing.

No.

Tricia is not of the opinion at all that wounds on trees can be transmitted to seedling plants. She was aware that trees can grow scars but that these scars cannot be passed on to seedlings at all.

Grade II

QUESTION-RESPONSE TABLE
2AII

			QUESTION I	QUESTION II	QUESTION III
			If a deep cut is made on the bark of a tree (e.g. rubber tree). Will the tree grow a scar?	If a tree is wounded and it heals its wound, would the scar formed be transferred to the offspring of this tree?	Suppose a tree has 20 branches and 10 of these branches were chopped off. Will the scars on these cut off branches show on the seedling plants?
NAME	AGE	TOPIC			
Sandra	7.6	Injuries of trees.	Yes.	No. Because the seed from which the seedlings grew were on a different part of the tree. (The seed has to fall off the tree before it starts to grow).	No. Because it would be a different part of the tree. So it would just have as many branches as could have.
Brenda	7.8		Yes, they can grow a new skin-- a scar. I have a scar on my chin.	No. The tree had a new layer of skin - m--m I forgot. Remove this picture.	Yes. Because the tree has some scars where they cut off some branches
Douglas	8.1		Yea, it grows a piece of protection.	No. Because - because... Like when the tree is wounded and the seeds came from the very top it would not be hurt - because it would still be growing at the top. So when you pick up the seeds quickly and grow them, nothing would happen to them - really.	Absolutely no. Because I have been growing chestnut trees and there is a huge hole that went almost through the tree and I am growing the chestnut (seeds) that came off the trees, the chestnut trees that I am growing they don't have it (the hole). But if you make the injuries very close to the seeds, it would be transferred.
Hughie	8.6		Yea.	The scar will not be transferred to the seedling. But the 'why' is a hard question to answer.	These scars will be transferred because they came from broken branches.

GRADE II

QUESTION-RESPONSE TABLE

2AII

QUESTION IV

If the leaves of a tree were cut in two halves (demonstrate with a leaf) when the tree was still a seedling plant, will this affect the shape of the leaves of the seedling?

COMMENTS

No. (implied)

Sandra explains that seedlings grow from seeds away from the parent plants, therefore she does not believe they could acquire deformities from their parents.

No.

The answers here are contradicting each other. But upon listening to Brenda's explanations it became clear why she answered as she did. To her, the scar left behind by peeling the bark of a tree is a different scar from that left by cutting down the branch of a tree. The bark can grow again a new bark in place but the stumps cannot. Therefore the branch's scars can be transferred to the seedlings but the bark's scars cannot.

No, it won't affect the seedling.

It appeared from Douglas' first answer that proximity of injury to the bearing organ of the tree has significance in terms of whether the injury would be transferred. When this idea was checked for in the 2nd picture with branch injuries, Douglas denied positively that the injuries cannot be transferred, basing his argument on his experience with the chestnut tree.

No. The wound in the leaves won't be transferred but it is a hard question to explain why.

When Hughie was asked why the scars from broken branches would be transferred and not the ones from peeled off bark, he explained that because in this case the branches are completely removed from the tree.

Grade III

QUESTION-RESPONSE TABLE
2AIII

NAME	AGE	TOPIC	QUESTION I	QUESTION II	QUESTION III
			If a deep cut is made on the bark of a tree (e.g. rubber tree). Will the tree grow a scar?	If a tree is wounded and it heals its wound. Would the scar formed be transferred to the offspring of this tree?	Suppose a tree has 20 branches and then 10 of these branches were chopped off. Will the scars of these cut off branches appear on the seedling?
Nancy	9.00	Injuries on trees.	Yes, they do.	No. I don't know why.	The scar will not be transferred.
Michael	9.2		Yes, I have got a scar right there.	The scar won't be transferred. Because it was just a bruise on its mother.	If the branches are removed, this will be transferred to the seedling. Because this is now cutting off branches.
Sylvia	9.5		Yes, trees can have a scar.	No. It is a different kind (tree). It is not the same as this one.	No. It is a different kind of tree again.
Gary	10.1		Yes.	It won't have this scar.	No, they won't get it.

Grade III

QUESTION-RESPONSE TABLE

2AIII (cont'd.)

QUESTION IV

If the leaves of a tree were cut in two halves (demonstrate with a leaf) when the tree was still a seedling, will this affect the shape of the leaves of the seedling?

COMMENTS

The baby plants won't have the cut up leaves. Because the leaves will grow. The young plants grow their own leaves.

Again Nancy recognizes that scars and injuries on plants cannot be handed down to their seedlings-- "they grow their own leaves".

No.

He explained that in plants the bruise will not be transferred to the young plant because it is not an animal. They are not alive like humans and dogs.

No. It is a different tree.

Sylvia recognizes that young trees come fresh, they do not acquire injury marks from their parents.

No. (implied)

The subject does not believe that seedlings could inherit injury marks from their parent plant. Some communication problems were encountered as English was a 2nd language for this subject.

Grade IV

QUESTION-RESPONSE TABLE
2AIV

			QUESTION I	QUESTION II	QUESTION III
			If a deep cut is made on the bark of a tree (e.g. rubber tree). Will the tree grow a scar?	If a tree is wounded and it heals its wound. Would the scar formed be transferred to the offspring of this tree?	Suppose a tree has 20 branches and then 10 of these branches were chopped off. Will the scars of these cut off branches appear on the seedling?
NAME	AGE	TOPIC			
Kenneth	9.10	Injuries on trees.	Yes.	No. If the bark was taken off how would it affect the seedlings on top of the tree?	It might, but I am not sure. It is easier to transfer less than more branches.
Trevor.	10.1		Yea.	No. Not so really. The scar would still grow in.	Every tree has a different number of branches. (No, they won't be transferred).
Paula	10.2		Yes.	No, except if the wound were such that it obstructed the water supply of the plant. No, the scar will not be transferred, but the seedling might not grow as well.	No, it won't affect the leaves of the seedlings. (implied).
Shannon	10.2		Yes.	Looks like it would not. Because it is a seed so it would not have a scar there. Most likely not. So I guess it would not have a scar.	No, I don't think so. Like the tree grew with branches and he had them cut off. So when the seeds come down, they are not attached (to the parent).

Grade IV

QUESTION-RESPONSE TABLE

2AIV

QUESTION IV

If the leaves of a tree were cut in two halves (demonstrate) when the tree was still a seedling, will this affect the shape of the leaves of the seedling?

COMMENTS

The leaves would probably be short. If all the leaves were cut in half and the seedling were grown on the branches by the leaves, they fell off too, the leaves would probably be short. (proximity of injury to seeds determined the transfer.

The short leaves will not be transferred. I guess it does not really happen that way.

No, it won't affect the leaves of the seedlings. (implied)

This would not affect the seedlings' leaves.

When Kenneth was reminded about the apparent contradiction of this explanation to that for the dog, he explained that puppies grow inside the mother's body, but seeds do not - they grow on braches.

Trevor does not believe scars and wounds on plants can be given to seedlings. When asked to explain the differences for plants and dogs, he says he does not know, but he guesses things don't happen that way in plants.

Paula does not believe at all that injuries can be handed down to seedlings. She cites her illustration from what she sees people do to trees around.

When the contradiction between this explanation on tree scars and tails of dogs was brought to Shannon, she said that in dogs babies grow inside the mother but in trees seeds grow on branches and in the soil.

Grade V

QUESTION-RESPONSE TABLE

2AV

QUESTION I				QUESTION II		QUESTION III	
If a deep cut is made on the bark of a tree (e.g. rubber tree). Will that tree develop a scar?				If a deep cut is made on the bark of a tree and a scar is formed, will the seedling of this tree have this scar transferred to it? Why?		Suppose a tree has 20 branches. If 10 of these branches are chopped down, will the resulting scars be transferred to the seedling of such a tree?	
NAME	AGE	TOPIC					
Jun	10.6	Injuries on plants.	Yes.	Yes. If the wound was done before the seeds are on the tree, then the scar would be given to the seedling. But if it is done when the seeds are already there it would not be given into the seeds.		Yes, it would have these scars.	
Stephen	10.9		Yea.	I think the baby plant would have a scar but it would not show very much, as it grows older and older the scar grows bigger and bigger.		Yes, the scar would be transferred. (implied)	
Marla	10.11		Yes, when a mark is left.	It is not going to be on the new trees that grow. Because these seeds have been up there, and might not get everything, so they might not turn on.		No, I don't think the scars would be transferred. Because this plant was not born with that, the man did it.	
Susan	11.1		Yes.	No, I don't think it will. Because it only happened to this one (the parent). A person came and peeled it off.		No, I don't think so. Because the person has not come and taken off the branches yet. Here it is just seeds coming out of the tree and somebody plants it way from this tree (parent). So it won't be transferred.	

Grade V

QUESTION-RESPONSE TABLE

2AV (cont'd.)

QUESTION IV

If the leaves of a house plant were cut in two halves (demonstrate with a leaf) when the plant was a seedling, will this affect the shape of the leaves of the seedling from this tree?

COMMENTS

Yes, the cut leaves would be transferred.

Jun has again resorted to the significance of time of injury for the deformity's transmittance. It was this same explanation he gave for the cut tail in dogs.

Yes, it would affect the seedlings (implied).

Stephen quite clearly says that plants inherit scars from their parents but in miniscule form. As they grow older each day, the scars grow bigger and bigger.

No, it would not affect the leaves of the seedlings.

Marla recognizes that something done on the plants cannot be transmitted. When the contradiction between this explanation and that for dogs was brought to her notice, she was not able to explain herself.

No, it would not affect the leaves.

Susan explained her contradiction between trees and dogs that in trees, the seeds grow away from the parent tree.

Grade VI

QUESTION-RESPONSE TABLE

2AVI (cont'd.)

QUESTION IV

If the leaves of a house plant were cut in two halves (demonstrate) when the plant was a seedling, will this affect the shape of the leaves of the seedling from this tree?

COMMENTS

The leaves of the seedling won't be affected.

This contradictory explanation to that of dogs was brought to Sarah's notice. She said a tree hardly ever looks like where it comes from (parent) but a dog usually looks like its parent with most of the physical features. She gives the example that a mother orange tree could have bad oranges but the seedling from it could give healthy oranges.

The seedling would be normal (implied).

Richard is quite aware the seedlings grow from normal seeds, so no way would the injury on the parent affect the seedling.

No, it won't affect the seedling leaves.

Eric is quite convinced that the scars won't.

No, it would affect the seedlings (implied).

Gaelen believes that wounds on trees cannot be transferred to the seedlings.

Grade VI

QUESTION-RESPONSE TABLE
2AVI

QUESTION I				QUESTION II		QUESTION III
If a deep cut is made on the bark of a tree (e.g. rubber tree). Will this tree develop a scar?				Suppose a deep cut is made on the bark of a tree and a scar formed; will the seedling of this tree have this scar transferred on to it? Why?		Suppose a tree has 20 branches. If 10 of these branches are chopped down, will the resulting scars be transferred to the seedling of such a tree?
NAME	AGE	TOPIC				
Sarah	11.2	Injuries on plants.	Yes.	No, the scar would not be transferred. The scar would have nothing to do with it because most of the time it does not grow up to look like the tree from where it came from. Generation after generation of peeling would not affect the seedling because a tree does not look like the mother.		No, it is the same like before. No tree looks the same. Like you can cut a tree to a stump and it will still grow again like before.
Richard	11.4		Yes.	No, I don't think so. I am pretty sure they won't. They grow from seeds and I would think they would not have scars in the seeds.		No, I don't think the scars would be transferred, because there are no branches to give seeds here anymore, the other branches give the seeds - normal seeds. It would not affect the number of branches on the seedling. The seedling would be normal.
Eric	11.10		Yea.	I don't think so. No, because when it has seeds, the seeds just fall off the tree, way--away from the parents' area, they just grow away.		No, I don't think so. It won't.
Gaelen	11.11		Yes.	No, the seedlings won't be affected.		No. Because the branches were cut off. So it wouldn't have an affect on the seedlings.

Grade VII

QUESTION-RESPONSE TABLE
2AVII

			QUESTION I	QUESTION II	QUESTION III
			If a deep cut is made on the bark of a tree (e.g. rubber tree). Will this tree develop a scar?	Suppose a deep cut is made on the bark of a tree and a scar formed; will the seedling of this tree have this scar transferred on to it? Why?	Suppose a tree has 20 branches. If 10 of these branches are cut down, will the resulting scars be transferred to the seedling of such a tree?
NAME	AGE	TOPIC			
Tony	12.6	Injuries on trees.	Yes.	The seedlings won't have a scar. It is something like that---the dog.	No, it would not affect the seedling.
Sergio	12.6		Yes.	I don't think they will. Because it is different in trees. When trees have seeds, these seeds grow up normally.	The same as in the case with the bark. The seedling would probably be normal
Sandra	12.8		Yes, the teacher told us that.	The scar will show on the seedling but only a small one.	It will get some of the scars, not all but just two or three of them.
Liza	13.5		Yes, a notch.	No, I don't think so. Like if I got hurt I don't think it would get transferred unto my children.	No, it won't affect the seedling tree.

Grade VII

QUESTION-RESPONSE TABLE
2AVII (cont'd.)

QUESTION IV

If the leaves of a house plant were cut in two halves (demonstrate), will this affect the shape of the leaves of the seedlings from this tree?

COMMENTS

No, it won't affect the seedling.	Tony explains the issue of the non-transfer of injuries on trees in terms of what he knows happens to dogs and human beings.
Seedling leaves would be normal. But if the injury was done when the tree was young, then the leaves of the seedling would be cut off.	Sergio also differentiate inheritance in trees and in dogs. He makes analogies with human beings to explain the tree phenomenon. He is deceived by time in the case of the leaves.
Yes, the shape of the seedlings will be affected.	Sandra is convinced that on a small scale injuries on the back of a tree can be transferred on the skin of the seedling plant.
No, it wouldn't affect the seedling leaves.	Liza does not believe at all that injuries on trees can be transferred to the seedling.

Grade VIII

QUESTION-RESPONSE TABLE
2AVIII

			QUESTION I	QUESTION II	QUESTION III
			If a deep cut is made on the bark of a tree (e.g. rubber tree). Will this tree develop a scar?	Suppose a deep cut is made on the bark of a tree and a scar is formed; will the seedling of this tree have this scar transferred on to it? Why?	Suppose a tree has 20 branches. If 10 of these branches are chopped down, will the resulting scars be transferred to the seedling of such a tree?
NAME	AGE	TOPIC			
Vivian	13.00	Injuries on trees.	Yes,	No, the seedling won't have the scar. Seedlings would be different because they grow their own bark.	It doesn't affect the branches of the seedling. They would have their own branches.
Kelly	13.7		Yes.	No, because the seeds are separate from the tree.	No, it won't affect the seedling.
Walter	13.8		No, it will only dry up. There is a tree just in front of my house which I gave a wound with a knife about 5 years ago. I went there afterwards, the wound was still there but it is dried up and not fresh.	No, the wound won't be transferred to the seedling, because it is already big.	No, it won't affect the seedlings. The branches first of all will grow back on the tree.
Mike	13.10		Yes, they grow a new bark.	No, I don't think so. The plant grows from the seed, and the seed was not affected.	No, I don't think so. Well, it is again with the seeds.

Grade VIII

QUESTION-RESPONSE TABLE
2AVIII (cont'd.)

QUESTION IV

If the leaves of a house plant were cut in two halves (demonstrate), will this affect the shape of the leaves of the seedling from this tree?

COMMENTS

It would not affect the leaves of the young plant. The cut leaves will eventually fall off and the tree grows new leaves.

Vivian is quite clear on the question of transfer of inherited material in plants.

No, it won't have any effect on the shape of the leaves.

Kelly is also quite clear on the issue of injuries and inheritance in plants.

It would not affect the seedling because the plant will grow new leaves.

Walter explained that injuries in plants will not be transferred because they will grow new leaves and new branches when older ones are cut down.

It would not affect the shape of the leaves of the seedling.

The injury phenomenon on trees is quite clear to Mike - it cannot be inherited.

Grade 1

QUESTION-RESPONSE TABLE
3AI

NAME	AGE	TOPIC	QUESTION I	QUESTION II	QUESTION III
			Suppose in a train accident a man lost one of his fingers/toes. If this man has a child how many fingers/toes will he have?	Suppose a man and his wife both lost their thumbs in a train accident. If they have a child afterwards, how will this child be?	Suppose another couple were involved in a car accident in which they lost their eyesight. If they have a child will he be affected?
Christina	5.6	Injuries of man	I don't know	--	--
Johnnie	7.4		His child will not lose a finger - because the baby was never in the accident.	The child would be normal. (implied)	The child would not be blind. I don't know why. It is too hard (to explain).
Jamie	7.4		Man? Men cannot have babies. No.	Yes, the child will have a finger there. Just because the mummy's own finger is cut off doesn't mean the baby's own is going to get off.	No, he will not be blind (implied).
Tricia	7.5		The child would just be as some one who did not have any fingers cut off. This is because they are different people and have to have theirs cut off too.	Normal.	The child will be able to see. It is a different person. He has not got anything in his eyes that can stop him from seeing. So he can still see things.

Grade I

QUESTION-RESPONSE TABLE

3AI (cont'd.)

QUESTION IV

Suppose a small boy and a girl
lost their fingers when they
were just babies. If they get
married and have a baby, will he
be affected?

COMMENTS

	Christina does not know what fingers or toes or thumbs are. Even when the investigator taught her what these body parts are, her answers were just the regular 'I don't know'. She must be fed up with the interview already as she indicated her tiredness earlier on.
They will have their own fingers	Johnnie recognize that these are environmental occurrences and cannot be transferred to the offspring-this is shown by his insistence that the young ones themselves were not involved in the accident. He was not deceived by duration of injury at all.
Their baby will have a finger	Jamie does not believe that men can have babies. No wonder he explained earlier on in the case of dogs, that the father dog can only transmit traits to the offspring through the care and attention he gives to the pups.
No, the baby will have fingers	Tricia does not confuse environmental features at all with inherited ones. Of all the subjects interviewed in grade one she showed the most developed concepts.

QUESTION-RESPONSE TABLE

3AII

Grade II

			QUESTION I	QUESTION II	QUESTION III
			Suppose in a train accident a man lost one of his fingers/toes. If this man has a child how many fingers/toes will he have?	Suppose a man and his wife both lost their thumbs in a train accident. If they have a child afterwards, how will this child be?	Suppose another couple were involved in another car accident in which they lost their eyesight. If they have a child will he be affected?
NAME	AGE	TOPIC			
Sandra	7.6	Injuries on Man	Maybe four fingers. Maybe five. Because the wife has five and the father has four, so it would be-- em --between the two.	The baby will be four fingered.	Blind probably. Because the mother and the father are blind.
Brenda	7.8		One finger would be missing. Because the person (father) had his finger cut off.	Their baby will be affected (implied).	Their child would be blind. Because the mother was blind.
Douglas	8.1		A man does not have babies. But if he has a wife with normal fingers, one child would have fingers like me (five) but another would have a shorter finger that grows slowly.	These babies would probably have no fingers.	The eyes (of the child) would open, it would take a longer time for them to open, like, maybe not three weeks but 7 months. It takes a longer time. It does not transfer like the dogs do. Anyway, I don't really know.
Hughie	8.6		His child will have ten (10) fingers. Because his children did not get cut off. If it is a lady who is wounded, her baby will show the scar.	As long as it is a lady who is wounded the child will show the scar too.	Their child would lose a finger as long as the mother has lost her finger.

Grade II

QUESTION-RESPONSE TABLE

3AII (cont'd.)

QUESTION IV

Suppose a small boy and a small girl
lost their fingers when they were
just babies. If they get married
and have a baby, will he be
affected?

COMMENTS

Their child would be affected
(implied).

It is quite apparent that Sandra cannot
differentiate environmental traits from
those inherited particularly in animals
and humans. The logic behind this mis-
conception is very interesting indeed.
In human the baby grows in the mother's
womb but in plants the seedlings grow
away from the parents.

The child would be abnormal
(implied).

Brenda holds on to her previous logic in
the case of the dogs, that once the parents
are injured the injury would affect the child
born to the parents. She believes the deformity
will be genetically coded and handed down to
the offspring.

He will be affected
(implied).

Douglas qualifies that the transfer of injuries
in dogs is not the same as in man. In dogs the
deformities are transferred whole sale as in the
parent. But in man these would only be retardation
in growth of fingers of the offspring and lateness
in opening of eyes after birth.

The child would lose a finger as
long as the mother has lost her
finger.

Hughie emphasize the point right through that it is
only when the female parent is injured does he feel the
deformity would be transferred to the babies. If
it is the father who is blind the child won't be blind.

Grade III

QUESTION-RESPONSE TABLE

3AIII

			QUESTION I	QUESTION II	QUESTION III
			Suppose in a train accident a man lost one of his fingers/toes. If this man has a child, how many fingers/toes will he have?	Suppose a man and his wife both lost their thumbs in a train accident. If they have a child afterwards, how will this child be?	Suppose another couple were involved in another car accident in which they lost their eyesight. If they have a child will he be affected?
NAME	AGE	TOPIC			
Nancy	9.00	Injuries on Man	The man's child will have full (number of) fingers.	The baby will be normal.	Their baby will be normal (implied).
Michael	9.2		The child's finger might really be short. One finger will really be small right through his life.	The baby's fingers on one hand would be short and maybe on the other hand maybe short also.	The baby will look like his parents. If the parents were hurt, the baby might be blind. That's how the baby will be born.
Sylvia	9.5		No, they would have five fingers.	No, the child would have five fingers because he's a new person.	Their children would have five fingers in each hand.
Gary	10.1		His child will have ten fingers - normal. Because the man use to have ten--right? So the baby will grow the fingers the man use to have.	The baby will be normal.	Their baby will see. Because the woman used to have normal eyes and so the baby will be like her too.

Grade III

QUESTION-RESPONSE TABLE

3AIII (cont'd.)

QUESTION IV

Suppose a small boy and a small girl
lost their fingers when they were just
babies, If they get married and have
a baby, will he be affected?

COMMENTS

Their baby will be with the finger.
Because the mother is not like the
baby. She had an accident and the
baby did not have the accident.

The baby will look like his parents.
If the parents were hurt, the baby's
fingers might be chopped off.
That's how the baby will be born.

Their children would have five
fingers in each hand.

Their baby won't be affected
(implied).

Nancy does not believe that the injuries can be
transferred to the babies. However, she is able
to distinguish accidental injuries from inherited
traits.

Mike believes that injuries can be transferred
and that if it is the right hand of the mother or
father which is affected, the right hand of the
child would be the one affected also.

Sylvia explained that even though some babies come
with fault from birth, yet most children come
normal. And that if a parent breaks a hand it does
not mean the baby would be like that.

Gary is able to recognize that once the mother was
normal before, the child will be normal also when
it is born.

Grade IV

QUESTION-RESPONSE TABLE

3AIV

NAME	AGE	TOPIC	QUESTION I	QUESTION II	QUESTION III
			Suppose in a train accident a man lost one of his fingers/toes. If this man has a child how many fingers/toes will he have?	Suppose a man and his wife both lost their thumbs in a train accident. If they have a child afterwards, how will this child be?	Suppose another couple were involved in another car accident in which they lost their eyesight. If they have a child, will he be affected?
Kenneth	9.10	Injuries on Man	I think the child will have very short finger.	Probably it would not have a finger.	Probably, the baby would be blind.
Trevor	10.1		I could say the child would probably not have a finger. I think it is probably like in the dogs. They would have what their parents have.	The child would have a short finger. Children have what their parents have.	It could be either. It probably would come blind or it might not, if it was lucky. But it probably has a better chance that it might grow blind.
Paula	10.2		I don't think that it will affect him - e-m-my best friend's mother, like her father got his finger chopped off in a car, it did not affect my friend's mother.	It would not be transferred.	They maybe blind - I am not sure - it is really a 50-50 chance. I don't know really.
Shannon	10.2		I think the child will be normal. Because the mother was born normal.	I guess the baby would still be normal.	The baby would be normal (implied).

QUESTION-RESPONSE TABLE
3AIV (cont'd.)

Grade IV

QUESTION IV

Suppose a small boy and a small girl lost their fingers when they were just babies. If they get married and have a baby, will he be affected?

COMMENTS

Their baby will have a short finger (implied).

To Kenneth, if it is only one parent who lost a finger, the child will develop a short finger but if it is both parents who lost their two fingers, then the child will be born with no finger.

Their child would have a short finger.

Trevor has difficulty distinguishing between environmentally induced injuries and inherited traits.

It won't be transferred.

Even though Paula cites living examples to explain why a cut finger cannot be transferred she was confused when it came to the question of blindness.

The baby won't take after its parents' cut finger. It depends, the baby could have fingers or the baby couldn't have fingers. It depends. I am not sure (she is confused).

When the contradiction between this explanation and that of the dog was brought to Shannon's notice, she says human beings are different to dogs. She got confused.

Grade V

QUESTION-RESPONSE TABLE

3AV

			QUESTION I	QUESTION II	QUESTION III
			Suppose in a train accident, a man lost his finger/toes. If he becomes well and has a baby after, will his baby be affected?	Suppose a man and his wife both lost their thumbs in an accident, if they have a baby after they have recovered, how will their own baby be?	If a boy and a girl lost their thumbs/fingers when they were just babies (e.g. 1 year old). If they grow up and have babies, how will their babies be?
NAME	AGE	TOPIC			
Jun	10.6	Injury on Man	I think his child will have five (normal). Because the man did not have four fingers all his life. I don't think it had enough time to form in his system.	Normal, because the parents did not have the problem all their lives.	The baby won't be blind. Because the parents are already big.
Stephen	10.9		If the man had three children, two could be alright like the mother and one could be like his father. The child's finger could still be there but he could not move it, or it could be a different finger or his wrist - he could not move it forever.	If they had again three children, two of the children could be like their father or mother. They could have one or two fingers missing, but I would say most of them would be alright.	The child could see but there would be something wrong with his eyes - like they could be cross-eyed or he'd have to wear glasses.
Marla	10.11		I think, normal. Because the accident just happened to the man after that he got married.	Maybe the child will be missing a finger. Because the mother and father both have it. This does not happen all the time--only when something really bad.	I think the child would be blind. But if it is just one parent who is injured, then it would not be affected---it could but I don't think so.
Susan	11.1		I think the baby would still have ten-like five on each hand. Because it should not affect the baby--Because it happened just to the man and the lady had good fingers.	I think that the fingers (of the baby) might be a bit shorter because the mother and father both had them off.	I don't think the child's eyes would be very good at seeing things. Because the baby came from the mother and the father.

QUESTION-RESPONSE TABLE

Grade V

3AV (cont'd.)

QUESTION IV

If a boy and a girl lost their thumbs/fingers when they were just babies (e.g. 1 year old). If they grow up and have babies, how will their babies be?

COMMENTS

I think there will be only four fingers on the baby.

Jun believes that the longer one has a deformity the more there are chances for it to be adopted by his/her system and given over to his/her children. Once one is getting older and older, the chances grow slimmer and slimmer.

The baby would be affected but not necessarily on their fingers; could have missing hand on to the elbow or an unmoving wrist.

Stephen again reiterates the point that the wounding of either the finger or the eyes would not necessarily lead to similar injury on the child. He is convinced this feature would be transmitted but it would manifest itself in various ways on any part of the child's body.

The child might have-be short on one finger-missing one finger. Because the mother and father both have it.

Marla reiterates that the injury has to be long with the parent to justify transfer. She also brings in a new factor and that is the severity of the injury. If it is a lesser injury it will not transfer but if it is severe, it stands a chance to be transferred to the child.

The baby would still have shorter fingers. Because it happened still to the mother and the father.

Susan holds on to the logic she used for dog deformities. Even in humans she says, once it is both parents who are injured the injury will be transferred. But if is just one parent, the manifestations is of a medium effect.

Grade VI

QUESTION-RESPONSE TABLE

3AVI

			QUESTION I	QUESTION II	QUESTION III
			Suppose in a train accident a man lost his fingers/toes. If he becomes well and has a baby after, will his baby be affected?	Suppose a man and his wife both lost their thumbs in an accident, if they have a baby after they have recovered, how will their own baby be?	If in a accident a man and his wife were injured and they lost their eyesight. If they have a baby after, will the baby be born blind?
NAME	AGE	TOPIC			
Sarah	11.2	Injuries on Man	No it won't be transferred to the child. But in every child there is a chance for deformity. My dad has a chopped finger, he had me but you know I am(O.K.)	Their child will not be affected. That's what happened to me.	They would probably not be blind. They would be able to see but they have a little chance of being blind. They might be affected but I doubt it.
Richard	11.4		It might but I am pretty sure it won't. The (lost) finger would not make that much difference to the birth,---the baby.	It just might, but I don't think think it will. But maybe if it had twins one might get it, one might not. The more babies you have the more chance you have of the hand getting cut off.	It depends on whether it is twins or a single child.
Eric	11.10		They would just be normal with five on each hand. Because the finger like the bones have nothing to do with it.	I would say normal because dogs are different to human beings.	Normal.
Gaelen	11.11		Oh no. Because my mother had an infection there and that did not affect me.	No, that wouldn't affect the child, because it is only physical. If it were inside the body, then it would affect the child. But not when the injury is outside i.e. physical.	No, the child would be normal.

QUESTION-RESPONSE TABLE

Grade VI

3AVI (cont'd.)

QUESTION IV

If a boy and a girl lost their thumbs/finger when they were just babies (e.g. 1 year old). If they grow up and have babies, how will their babies be?

COMMENTS

Their child will not be affected.

Sarah brings her own case as an example of the phenomenon in question. Because of her belief in a chance for every child to be deformed, she thinks the blindness might affect the child; but she doubts if this is going to be the case anyway.

It depends if they have twins or a single child. If they have twins there is more chance of having a chopped off finger or half-finger.

Richard doesn't see any similarity in the issue of transfer of injury between humans, dogs and plants at all. He sees these organisms with different inheritance mechanisms. The probability of transfer of injury increase with the increase in the number of children per birth.

Normal---because it is same as the man and the lady.

Eric says that human beings do not transmit injuries to their young. He explained this difference between dogs and humans on the grounds that they are different organisms.

The child won't be affected (implied).

Although Gaelen did not mix up inheritance and environmental features, her use of "physical" means external body parts, while to her internal organs have much to do with inheritance particularly when it comes to transfer of injuries to offspring.

QUESTION-RESPONSE TABLE

Grade VII

3AVII

			QUESTION I	QUESTION II	QUESTION III
			Suppose in a train accident a man lost his fingers/toes. If he becomes well, and has a baby after, will his baby be affected?	Suppose a man and his wife both lost their thumbs in an accident, if they have a baby after they have recovered, how will their own baby be?	If in a car accident a man and his wife were injured and they lost their eyesight. If they have a baby after, will the baby be born blind?
NAME	AGE	TOPIC			
Tony	12.6	Injuries on Man	He will have correct fingers.	The baby will have thumbs.	No, because some people get blind when they are young and when they get babies, the babies won't turn out blind.
Sergio	12.6		The children would be normal.	The baby won't be affected because it is only a misfortune of an accident.	They might grow up blind or they might have bad knees, that collapses right away.
Sandra	13.8		He would be normal because the mother is normal.	The child would have shorter thumbs.	They would have sight but not as good as normal kids would have.
Liza	13.5		I think the child would be O.K. I don't think it really makes any difference.	The baby will not be affected.	The baby will not be affected.

Grade VII

QUESTION-RESPONSE TABLE

3AVII (cont'd.)

QUESTION IV

If a boy and a girl lost their thumbs/fingers when they were just babies (e.g. 1 year old). If they grow up and have babies, how will their babies be?

COMMENTS

Regular, normal.

Tony does not confuse injuries at all with inherited traits.

When you are younger, there is more of a chance that there would be an effect on the baby. Same as in the dogs, it would affect their growing cycle.

Sergio shows quite an inconsistent logic in the case of the thumb and the eye injury. In one case it is transferred, in the other it is not. He is again deceived to believe that the younger the person is when he is injured, the more there are chances for this injury message to be registered in one's inheritance code.

The child would be normal but with shorter fingers, just like I said earlier. The longer the time, the shorter will the finger be.

Sandra is of the opinion that deformities can be transferred to the offspring. The longer the parents have the injury, the more intense the transfer on the children. If only one parent is injured, then there is no transfer.

It will not affect the child.

Liza clearly sees that the injuries on humans will not affect the child at all.

Grade VIII

QUESTION-RESPONSE TABLE

3AVIII

			QUESTION I	QUESTION II	QUESTION III
			Suppose in a train accident a man lost his fingers/toes. If he becomes well, and has a baby after, will his baby be affected?	Suppose a man and his wife both lost their thumbs in an accident; if they have a baby after they have recovered, how will their own baby be?	If in a car accident a man and his wife were injured and they lost their eyesight. If they have a baby after, will the baby be born blind?
NAME	AGE	TOPIC			
Vivian	13.00	Injuries on Man	No, it wouldn't be affected.	No, it would not affect the child.	The child won't be affected
Kelly	13.7		No, it won't affect his child.	No, it won't for the same reason I gave earlier.	No, the child won't be blind.
Walter	13.8		No, it won't. I don't think so. This did not happen naturally, it was cut off. So it won't affect the child.	The child would be normal, leading a normal life. Even if a limb of a person is cut, there is no way that it can affect the child.	I don't think the child would be born blind. The parents were not born without eyesight.
Mike	13.10		No, the child will have a toe. Because the man is already mature.	No, it won't affect the child.	No, I don't think it would affect the child.

Grade VIII

QUESTION-RESPONSE TABLE

3AVIII (cont'd.)

QUESTION IV

If a boy and a girl lost their thumbs/finger when they were just babies (e.g. 1 year old). If they grow up and have babies, how will their babies be?

COMMENTS

Their child will be just normal.

Again Vivian was quite clear on the question of injury transfer in Man. She does not confuse environmental features to those inherited at all in Man.

No, it won't affect their child.

Kelly does not mix up her ideas at all about inheritance and injuries.

I have no idea. This is not the same with dog because a dog is a different animal, species. The dog has a whole different type of body.

Walter realized that probably giving an answer for this last question would contradict with his earlier logic for the dog, hence he clearly knows that in humans, wounding a child early in life does not change what is inherited so he said he does not know the answer to the question.

I think it would affect the child because the boy and the girl are not mature yet. It would still be growing up. Because his brain would sense that one toe/finger was missing and would record this.

When Mike was reminded about the contradiction of this last explanation to that for dogs he says-- the human brain is more developed and it would know more about it, than an animal whose brain is less developed. Well the plant has no brains so there is no question about transfer.

Grade I

QUESTION-RESPONSE TABLE
4AI

NAME	AGE	TOPIC	QUESTION I	QUESTION II	QUESTION III
			If this black dog (female) is to have puppies, what colour would the puppies be? Why?	If a white male dog and a black female dog have six puppies. What colour would their puppies be? Why?	Which one of the parent dogs do you think gives more colour to the puppies?
Christina	5.6	Relative contribution of parent = colour in dog.	They would be black because their mother is black.	White and black. Because their mother and father.	If there are six puppies, three of them would be black and three would be white. I don't think any parent gives more colour to the puppies.
Johnnie	7.4		Some could be white some could be black. Sometimes they could just come white.	I cannot think of anything. I don't know. Some may come with spots, brown, black.	Dogs get their colour from their mother. They do not get a color from the father because they were not born from him.
Jamie	7.4		Black. Because the dog is black. It could be brown and as it is growing older changes to black.	I would say they would be black, the mother always has the baby, right? So it should be that colour.	It is the mother who gives colour to the pups, because she has them and she takes care of them. The Dad can take care of them a little bit.
Tricia	7.5		I think they would either be all black or black and white, not just white. They would get the white from another dog or from the sun.	They could be white or they could be black and white or they could have brown. From the sun or the mixture of Mum and Dad together, that could give brown.	The mother and the father give the colour to the pups.

Grade I

QUESTION-RESPONSE TABLE
4AI (cont'd.)

QUESTION IV

Can puppies have any other colour
apart from the colour of the parent
dog? Why?

COMMENTS

They could be brown. I don't know.
White dogs-getting washed like it
happened to my dog too when we
washed it. It had little white
spots on its fur.

Brown, maybe. I don't know.

It could be brown. I don't
know.

Yes, they could get other
colours from the sun. When
the sun shines on you and then
you start turning light.

She does not believe that any one of
the parents could give more colour than
the other to the puppies. She believes
in the equal contribution of the father
and the mother to the puppies' colour
hence she said 3 will be black, 3 white.

To Johnnie, the pups could be white or
they could be black because they just
come that way.

Jamie believes that dogs could have various
colours but that these colours change as the
dogs grow older e.g. from brown to black.
So age is significant variable in deter-
mining the colour of dogs.

Tricia recognizes that the father can also
contribute along with the mother to the
colour of the pups. But for those strange
colours which are not apparent on the
parent dogs, she says these colours are
given to the pups by the light from the sun.

Grade II

QUESTION-RESPONSE TABLE
4AII

			QUESTION I	QUESTION II	QUESTION III
			If this black dog (female) is to have puppies, what colour would the puppies be? Why?	If a white male dog and a black female dog have six puppies. What colour would their puppies be? Why?	Which one of the parent dogs do you think gives more colour to the puppies?
NAME	AGE	TOPIC			
Sandra	7.6	Relative contribution of a parent = colour in dog.	Probably black. Because their mother is black.	White and black or white or black together. Maybe three would be black, two would be mix, one would be white. You have more black because the mother is black.	The mother gives more colour to the puppies.
Brenda	7.8		Probably black. Because the dog (mother) is black.	Probably black. Because the mother is black.	It is only the mother who gives colour to the puppies (implied).
Douglas	8.1		If the mother has a father, and a grandmother and granddad, they would probably-all the colours should be about the same colour. It would be a mixture of the colour of the father and mother.	The babies (puppies) would be black and white. Not all of them-like four or three of them would be black and white and one would be another colour, like the other relatives-would probably be an odd colour-like goldy black.	The mother (implied).
Hughie	8.6		It will have puppies that are black.	They would be black because the mother is black. It's the mother who gave the babies, so it is the mother's colour.	The mother gives colour to the puppies.

Grade II

QUESTION-RESPONSE TABLE
4AII (cont'd.)

QUESTION IV

Can puppies have any other colour
apart from the colour of the parent
dog? Why?

COMMENTS

No.	Sandra believes that the mother contributes more colour to the offsprings than the father does. To her puppies can not have any other colour on them other than that of the parent dog(s).
No.	Brenda does not recognize the contributing role of a father to the features on offspring dogs. To her the puppies can only acquire the colour of the mother.
They may get goldy black or brown from relatives-grandma and granddad.	Douglas was able to recognize many factors beyond the mother and father which could be significant in determining the colour of an offspring. He mentions grandma and grandpa, the father dog, etc.
No.	Hughie does not recognize the significance of a father in terms of colour transmission in dogs. In the case of dogs, Hughie believes that only the mother can hand down its colour because she gives forth the babies.

Grade III

QUESTION-RESPONSE TABLE
4AIII

NAME	AGE	TOPIC	QUESTION I	QUESTION II	QUESTION III
			If this black dog (female) is to have puppies, what colour would the puppies be? Why?	If a white male dog and a black female dog have six puppies. What colour would their puppies be? Why.	Which one of the parent dogs do you think gives more colour to the puppies?
Nancy	9.00	Relative contribution of a parent = colour in dog.	The puppies would be black. Because the mother is black.	Black. Because the mother is black. The baby came from the mother.	The mother because the baby came from her.
Michael	9.2		Maybe white. Some would be black, some would be white because some pups don't take after their mother.	Some of them could be black and white together. Some could be black, some white. Two would be black. Two would be white. Two would be black and white together.	No one contributes more than the other. If the mother is black she gives more than the father. If the father is the black one, he gives more than mother.
Sylvia	9.5		Black. Because the mother is black.	Some might be black. Some might be white. Some might be spotted. Because their parents are black and white.	The female contributes more colour to the puppies. Because she is the mother. Because the baby comes out of her body.
Gary	10.1		Black. If she has teats that are black, she would have puppies that are black.	As long as the mother's teats are black (or white) that is the colour the puppies will be.	The mother because she has the teats.

Grade III

QUESTION-RESPONSE TABLE
4AIII (cont'd.)

QUESTION IV

Can puppies have any other colour
apart from the colour of the parent
dog? Why?

COMMENTS

No.	Nancy only recognizes the mother as the sole determiner of the colour of puppies. To her the role of the father and the ancestral line are inconsequential.
They might be different colour from the mother and father. I don't know where they will get these other colours from.	Mike does not believe in the dominance of one parent over the other. To him the dark colours have more strength over light ones and so will show more on the puppies' fur.
Maybe - like brown. I don't know (where from).	Sylvia recognizes that the father dog could contribute to the puppies' colour, but this contribution is only very minimal since it is from the mother's body the puppies come from.
Yes, if the teats are black (on a white dog) the pups would be black.	To Gary it does not matter what colour the parents are, the important thing is the specific colour of the teats from which the pups suck milk; that colour is what the pups would have.

Grade IV

QUESTION-RESPONSE TABLE
4AIV

NAME	AGE	TOPIC	QUESTION I	QUESTION II	QUESTION III
			If this black dog (female) is to have puppies, what colours would the puppies be?	If a white male dog and a black female dog have six puppies. What colour would their puppies be? Why?	Which one of the parent dogs do you think gives more colour to the puppies?
Kenneth	9.10	Relative contribution of a parent = colour in dog.	Probably a very dark colour-like black. Because the mother is black.	Their puppies would probably be black, with white spots. Because they cannot be two full colours at once.	I think the black because the black is a stronger colour than the white-usually.
Trevor	10.1		Well it depends on what colour the father is-like if he is white---- I don't know.	Could be either (colour) I guess. Could be a mixture or grey or something. Probably more would be black. I guess it is a dark colour.	Not anyone really.
Paula	10.2		Well, it sort of depends on what sort of colour the father is -- really.	Probably different colours, some might be mix, some might be black, some might be white.	Not any one really.
Shannon	10.2		Usually would be black-but it depends what colour the father is too-I guess.	Sometimes they are black and white-like if the mother-sometimes they are mixed. And other times they take after their mother, sometimes their father.	I am not sure but I think the mother might, because like she has the babies, but I am not sure.

Grade IV

QUESTION-RESPONSE TABLE
4AIV (cont'd.)

QUESTION IV

Can puppies have any other colour
apart from the colour of the parent
dog? Why?

COMMENTS

The puppies could but it does
not very often happen.

Kenneth believes that black colour is
stronger than white so the dogs will
mostly be black with white spots. He
was able to recognize that other colours
could appear on the puppies.

Yes, there might be. I don't
know (where from).

Trevor could not predict what the colour
of the puppies would be unless he knows
what the colour of the Dad is. To him
black is stronger than white. That is
the determining factor.

Maybe - I am not really sure..
I don't know where these colours
come from.

Paula recognizes the role of the father as a
contributor and she cannot predict from only
data related to the mother. She has to know
about the father too.

I think they do but I am not
sure. I am not positive.

Most of Shannon's answers are based on tentative
premises. She is not sure of all the predictions
she makes but she thinks this is how things will
be.

Grade V

QUESTION-RESPONSE TABLE
4AV

NAME	AGE	TOPIC	QUESTION I	QUESTION II	QUESTION III
			If a black (female) dog has a litter of puppies. What will the colour of these puppies be?	If a black female dog and a white male dog have six puppies. What colour would these puppies be? Why?	Which one of the two parent dogs do you think gives more colour to the puppies? Why?
Jun	10.6	Relative contribution of a parent = colour in dog.	The puppies would be black and white. They get the white from their father.	I would say three of them would be black and three of them white. Three of these would be girl and the other three would be boy.	No. I don't think any of them does (implied).
Stephen	10.9		Well, it depends what colour the father is.	Some might be black with spots. Some could be like their mother, some could be like the father.	Sometimes it is the mother at other times it is the father.
Marla	10.11		Some could be black and some could have white in them. I don't know where they would get the white from.	The puppies would be black and white. Two would be black, two white and two black and white.	The female gives more colour because she has the puppies. But she can't give all the colours.
Susan	11.1		I think they would have a bit of black in them and a bit of the male dog's colour.	Maybe black and white; all over-like spots. Some could be different with some other colour like brown or something.	No, I don't think anyone of them does give more colour than the other. The colour of the puppies is in between.

Grade V

QUESTION-RESPONSE TABLE
4AV (cont'd.)

QUESTION IV

Can the puppies have any other colour
apart from the colour of the parent
dog? Why?

COMMENTS

Brown. I don't know
(where from).

Jun recognizes the significance of the male dog in giving inherited material to the pups but he believes the male puppies take after their fathers and the female puppies after their mothers.

Yes, they could have other colours.
(He cites example from Siamese cats). He says these maybe two fathers-one puppy gets the colour from one father, the other from another father (if the mother has two puppies).

Stephen believes that the puppies making a litter have various fathers and they exhibit the various colours because of the different colours of the fathers from whom they come.

They could get-like-brown.
I don't know where they get
this other colour from.

Marla recognizes that the father dog contributes to the colour of the pups. But she believes that the mother gives more colour because she has the puppies.

Maybe brown.. I don't know.

Susan does not think anyone of the parent dogs can dominate the other. She says the colour is in between both parents.

Grade VI

QUESTION-RESPONSE TABLE

4AVI

NAME	AGE	TOPIC	QUESTION I	QUESTION II	QUESTION III
			If a black (female) dog has a litter of puppies, what will the colour of these puppies be?	If a black female dog and a white male dog have six puppies. What colour will these puppies be? Why?	Which one of the two parent dogs do you think gives more colour to the puppies?
Sarah	11.2	Relative contribution of a parent = colour in dog.	It depends on what colour the father was.	They would probably have a little black on them and a little white, some might be totally black, or totally white. I would be black. I would be white. 4 would be mixed. Because the father and the mother mix to have babies.	Unless one of them is a pure breed and another is not, otherwise they would contribute equal colour if they are both pure breeds.
Richard	11.4		The puppies would probably be black-most of them; I think probably have odd, some white specks. Because there might be something like that made; the body of the dog (mother). I am not sure.	Three of them would may be black, and then two would be white, and may be one would be black and white, speck.	I would say since it is the mother who is giving birth to the puppies, I would say she gives more than the father.
Eric	11.10		It depends on what colour the male dog is.	Some of them might be pure white with blackspots, white some of them would just be white. I don't know if there will be any ones with pure black. The kitten would be white just like the colour of the father.	The white is plenty because the male dog is white. The male could give more colour. I don't know why.
Gaelen	11.11		I don't know very much about dogs. Because I have never really had one. I have two cats anyway. The kittens would be same colour as their father.		The father contributes the colour of the kittens.

Grade VI

QUESTION-RESPONSE TABLE
4AVI (cont'd.)

QUESTION IV

Can the puppies have any other colour
apart from the colour of the parent
dog? Why?

COMMENTS

They would probably get brown.
I am not sure where from.
Because you sometimes have
characteristics that your
parents did not have. It might
be in the back-in the ancestors
of those dogs.

Yes, maybe different kind of
food but I don't think so.
I am not sure.

Maybe, but I don't know.

Yea, they could. They get
this from ancestors.

Sarah recognizes that pure breeds could
be dominant over non pure breeds. Other-
wise the features would just be a blend
if both parents are pure. She recognizes
that the other colours on the offspring's
could have come from the ancestors.

Richard recognizes that the puppies could
have a different colour from the parents
but he does not know how this comes about.
He believes the mother gives more colour
than the father.

Eric is convinced that it is the male dog
who determines more the characteristics of
the puppies.

Gaelen has problem answering questions related
to dogs because she says she does not know
much about dogs. She requested the examiner
to ask her the questions as they are related
to cats, because she only presently has cats.

Grade VII

QUESTION-RESPONSE TABLE
4AVII

			QUESTION I	QUESTION II	QUESTION III
			If a black (female) dog has a litter of puppies, what will the colour of these puppies be?	If a black female dog and a white male dog have puppies. What colour will their puppies be? Why?	Which one of the two parent dogs do you think gives more colour to the puppies?
NAME	AGE	TOPIC			
Tony	12.6	Relative contribution of a parent = colour in dog.	Some could be black, some could be brown, some could be blue etc. after their mother and father. Or they may not necessarily have to take after the mother or the father's colour.	Black and white, some maybe black, some maybe white. If they had 6 puppies, 4 of them would take after the mother or 3 and a few of them mixed colours. But majority will be the mother's.	The mother because she is closer to them, because the father is not always there, the mother will always be till they get older. The majority will take after her because they came from her body.
Sergio	12.6		That depends what colour the Dad was. They could be mixed, or-but you don't know that for sure. There are no certain colours that they have to come out.	Maybe black and white, striped, some might be black, some might be white.	Yea. Probably the female. Because it is from the female's body that they come. So it is most from the female.
Sandra	12.8		It depends on the male dog. If the father is brown and the mother is black, the puppy will be dark brown.	They would be light black. If the mother and the father are blended together, there is a greyish colour, light black. If there are 6 puppies, 4 would be greyish black, 1 black and 1 white.	Yes, the mother. It is the mother that has the babies so they will take more of the colour from her.
Liza	13.5		They would be black, but either their mother, father, grandmother or ancestry might have been white. So maybe they would be affected by this white.	I think they would be white because the puppies would usually look like their father. But if the ancestry is white, they would be affected by this white.	The puppies usually come out looking like the father.

Grade VII

QUESTION-RESPONSE TABLE
4AVII (cont'd.)

QUESTION IV

Can the puppies have any other colour apart from the colour of the parent dog? Why?

COMMENTS

Yes, they could. Maybe the colour of the mother and father mixed, but I don't know.

The explanation of Tony here does not reflect a carry over at all from his earlier theory about height in man. Here he thinks that the mother contributes more because she is the birth giver and caretaker.

Yes, it has happened before. That is just nature. I don't think anybody knows. I don't think they have found that yet. It is just a weird thing.

When the contradiction between this explanation for dogs and that for height in humans was brought to Sergio's notice, he said that there is a difference between animal and the human being. The differences are those of no of leg, hair colour, tails. These are the difference that makes the genetics of a dog different to that of man.

Unless she mates with another male dog, then the puppies can have a different colour.

Sandra believes that the mother gives more characteristics than the father because she deliever's the puppies. To her the pups will not get any other (alien) colour unless their mother mates with another dog who is not the legal father.

Yes, maybe from the father's ancestry.

Liza's opinion is that young pups look more like their father.

Grade VIII

QUESTION-RESPONSE TABLE
4AVIII

NAME	AGE	TOPIC	QUESTION I	QUESTION II	QUESTION III
			If a black (female) dog has a litter of puppies, what will the colour of these puppies be?	If a black female dog and a white male dog have 6 puppies. What colour will their puppies be?	Which one of the two parent dogs do you think gives more colour to the puppies?
Vivian	13.00	Relative contribution of a parent = colour in dog.	The puppies would be black, because she is black.	Some would be black, some white and maybe black with white patches or white with black patches. Maybe 4 would be white or one with black patches.	The mother dog (implied).
Kelly	13.7		The puppies would be black, because that is the kind of dog the mother dog is.	The puppies will be a mixture of black and white or white or black.	The mother dog contributes more colour because she has more to do with the puppies-they are inside her. The male dog does not have much to do with it.
Walter	13.8		Most of the puppies would be black. For the same reason that the child (regardless of sex) will be just as tall as the mother. The mother gave birth to them.	The puppies would get a black and white colour. 3 would be black, and 3 white. Because now I see the father dog who is white.	They both give equal contribution.
Mike	13.10		Probably black. Because it will be same colour as its mother hence it is inside its womb. The blood system and everything goes to the puppies.	Some puppies would be like the father and some would be like the mother. Some could be mixed-black and white. It is hard to say which number would be black or white or mixed. It depends sometimes.	Maybe the mother because she has them in the womb. The blood passes through them and their mother's body. So I guess the mother may contribute more.

Grade VIII

QUESTION-RESPONSE TABLE
(Cont'd.)

QUESTION IV

Can the puppies have any other colour
apart from the colour of the parent
dog? Why?

COMMENTS

Yes, from the mother's mother,
longtime you know or from the
father's mother.

Although Vivian's predictions are very
rigid, she suggests that other colours
could appear on the puppies and this
could have come from their ancestry.
But from the figures she gives it is
quite clear she thinks the mother gives
more colour than the father dog.

I don't think they would show
any other colour.

Kelly is not able to see beyond the
parent dogs' features.

Yes, I suppose they could. From
the breed of the parent dogs.
Dogs could also change colour as
they grow older.

There is a difference between Walter's
prediction here and that for height
in terms of relative contribution of a
parent. He clarified that dogs are
different to people

Yes, but I can't tell for sure
which colour.

Mike feels that in dogs the mother
gives more colour to the puppies than
the male dog because the puppies grow
inside the female dog's womb.

Grade I

QUESTION-RESPONSE TABLE

5A1 9

NAME	AGE	TOPIC	QUESTION I	QUESTION II	QUESTION III
			If a tall man and a short woman have a child: If this child is a boy how will he be when he is fully grown?	If the child is a girl, how will she be when she is fully grown?	Why is this so?
Christina	5.6	Relative Parent Contribution = height in man	He will be tall as his father.	She will be just as tall as her mother.	Because the boy is fully grown. Because she is grown too.
Johannie	7.4		The boy would be tall. Because the Dad is tall so he's gonna be tall.	She will be short because her mother is short.	Because the father is tall. Because the mother is short.
Jamie	7.4		He will be tall. Because the man is tall and if the boy looks like the man he is gonna be tall.	If she is going to look like her mother, she is going to be small.	Because the man is tall and the woman is short; right? So if the boy is gonna look like his father, I will say he will be tall and the girl will be short if she looks like her mum.
Tricia	7.5		The boy would be tall.	The girl would be short.	The man is tall and the boy is going to be a man. And the mother is short and she is a girl, so she will be short.

Grade I

QUESTION-RESPONSE TABLE
5A1 (cont'd.)

QUESTION IV

Do you know of any other things
which would make a child grow tall?

COMMENTS

No, I don't know.

Christina believes that the sex of the child determines which of the parent's features the child would acquire. She does not recognize any other factors coming into play.

No, I don't think so.

Johnnie as Christie above believes that if the child is a boy, he will be like the father and if she is a girl, she will be like her mother, when she is fully grown. He does not recognize any other variables taking part in the game of inheritance.

Yes, well if you eat the right foods, you can grow taller-- if you eat good foods; go on a diet when you should, not eat candy.

Jamie believes the child is got to look like one of the parents. If it is a boy it will look like its father and if it is a girl it will look like its mother. There are rudiments of a chance factor

Sometimes the boy is like his mother and the girl is like her father. Because the boy and the girl are both from the mother. The father only looks after the children when the mother has to go out.

She started off with rigid explanations but gradually changed to amore flexible theory.

Grade II

QUESTION-RESPONSE TABLE
5AII

NAME	AGE	TOPIC	QUESTION I	QUESTION II	QUESTION III
			If a tall man and a short woman have a child: If this child is a boy how will he be when he is fully grown?	If the child is a girl, how will she be when she is fully grown?	Why is this so?
Sandra	7.6	Relative Contribution of a Parent = height in man.	Quite tall.	She would be quite short.	The boy would be tall because its father is quite tall. The girl would be short because her mother is quite short.
Brenda	7.8		He would be tall. Because he is a boy.	Short. Because she is a baby.	Because the boy will be like the father and the girl like her mother.
Douglas	8.1		He would be as big as his mother.	Girls are usually smaller than boys. So she would be as big as her mother.	They would both be about the same size. I don't know why they would be just as tall as their mother.
Hughie	8.6		I think the child will be as tall as its father.	It will be just as tall as its mother.	Because if it is a boy it will be as tall as its father. If it's a girl she will be just like mother because the mother had her. Because she is a girl.

Grade II

QUESTION-RESPONSE TABLE
5AII (cont'd.)

QUESTION IV

Do you know of any other things
which would make a child grow tall?

COMMENTS

No, I don't.

Sandra does not recognize the importance of any other factors apart from the fact that the boy would be like his father, the girl like her mother.

If the child eats good food,
like apples, some pears.

Brenda believes like other earlier children that the boy will be like his father and the girl like her mother. However she was able to observe the importance of food as a contributing factor.

Foods:
Apple, carrots, celery, tomato,
onions.

The investigator had a rough time to lure this subject into the subject under investigation. He engages himself very quickly into issues that were quite different from the topic.

No, I don't.

Hughie does not recognize the importance of foods in determining growth. To him the child is going to be tall like the father if he is a boy and short like the mother if it is a girl.

Grade III

QUESTION-RESPONSE TABLE

SAIII

NAME	AGE	TOPIC	QUESTION I	QUESTION II	QUESTION III
			If a tall man and a short woman have a child: If this child is a boy how will he be when he is fully grown?	If the child is a girl, how will she be when she is fully grown?	Why is this so?
Nancy	9.00	Relative contribution of a parent = height in Man	About his father's size.	Her mother's size.	Because as his father grows older, he is becoming smaller and smaller.
Michael	9.2		Tall as his Dad because he is a boy.	She will be short like her mother.	Because she is a girl, she will take after her mother. The same with the boy and his father.
Sylvia	9.5		He will take after the woman because she is the mother.	Same thing. (She will take after the mother)	This is so because their father always work. And their mother always stays home.
Gary	10.1		He will be big (tall). Because he's grown and he eats food.	She will be short.	Because a man is big and a woman is short.

QUESTION-RESPONSE TABLE

5AIII (cont'd.)

QUESTION IV

Do you know of any other
things which would make a
child grow tall?

COMMENTS

Eating meat.
I don't know any other.

It is really interesting how Nancy views the overtaking of height attainment by a child. He is of the opinion that fathers regress in height as they grow older and older and as such, their children gradually equal them in height.

I don't know if this is right
but being a vegetarian.
Eating vegetables.

In as much as Mike believes height of a child is inherited according to sex from the respective parents, he recognizes that foods--vegetables, can also be a determining factor.

No.

Sylvia believes that children take after people who are constantly in touch with them. Hence her belief that all children take after their mother as their father always goes to work. She does not recognize any other factors at play.

Maybe food--milk.

Although Gary recognizes the role food plays in helping growth, he believes that the girl will be shorter than the boy because women are smaller than men, usually. So to him it is not the question of the height of the mother or father, it is the question of the natural course of things.

Grade IV

QUESTION-RESPONSE TABLE

5AIV

NAME	AGE	TOPIC	QUESTION I	QUESTION II	QUESTION III
			If a tall man and a short woman have a child: If this child is a boy how will he when he is fully grown?	If the child is a girl how will she be when she is fully grown?	Why is this so?
Kenneth	9.10	Relative contribution of a parent = height in Man	Probably he will be tall.	She would probably be short, probably about the height of her mother.	Because his father is tall. Because her mother was short, she is probably going to be short.
Trevor	10.1		I would say about as big as the man. Usually boys grow as big as their father.	Probably the mother's size. Girls are usually smaller than boys.	Usually boys grow as big as their fathers. Girls are usually smaller than boys.
Paula	10.2		Probably, like his father, as tall as his father.	Probably around the size of her mother, maybe a bit bigger.	I don't know why.
Shannon	10.2		I think, he'd probably be tall, quite tall. I am not sure though. (It depends).	I guess it might be short or in between, or take after the mother - I am not sure though.	Because he might take after his father or mother.

QUESTION-RESPONSE TABLE

Grade IV

5AIV (cont'd.)

QUESTION IV

Do you know of any other things
which would make a child grow
tall?

COMMENTS

Good foods such as milk,
fruits; having a balanced
meal.

Kenneth seem to use the idea of
probability very much in presenting
his beliefs. This shows the tentative
nature of what he was saying. Although
on first instance he was not able to
remember any things as contributors to
height, he recognized food when it was
suggested by the investigator.

No. Probably some foods-
like vegetables.

Trevor is of the belief that boys usually
are as big as their fathers. Girls are
usually smaller than boys, so the girls
will be like their mother.

Proper eating, good exercise--
fruits, apples, oranges,
bananas.

Paula uses very tentative predictions by
her constant use of 'probably'. She
recognizes food and exercises as
contributing factors to a child's height.

Well by eating good foods.

Shannon makes predictions which she based
on probability. She says she was not sure
about her predictions as they could turn
otherwise. She names good foods as
contributors.

Grade V

QUESTION-RESPONSE TABLE

SAV

NAME	AGE	TOPIC	QUESTION I	QUESTION II	QUESTION III
			If a tall man and a short woman have a child: If the child is a boy, how tall will he be when he is fully grown?	If the child is a girl how tall will she be when she is fully grown.?	Why do you say so?
Jun	10.6	Relative contribution of a Parent = Man	About same as his father. Because he is a boy.	She will grow up like her mother.	Because he is a boy. Because she is a girl.
Stephen	10.9		The child will be medium; but he will be more towards his mother's size.	The girl will be more like her father.	Well, his father is tall and his mother is short, so he will be medium. Sometimes girls take after their father and boys after their mother. Because the child might want to be different. If he is already a boy he has to have something of the mother too.
Marla	10.11		Maybe as tall as the father. Boys grow taller.	Maybe a little past the mother. I don't know.	Because boys grow taller (than girl girls).
Susan	11.1		I think he would be in between. Because it is the mother and the father's baby, so it takes after them.	I still think it would be in between.	Because they are both the mother and the father's babies. so they will take after them.

Grade V

QUESTION-RESPONSE TABLE

5AV (cont'd.)

QUESTION IV

What other things do you think
would make a child grow tall?

COMMENTS

He should eat in the proper time
and sleep in the proper time.

To Jun even though he believes the sex
of the child determines who of the parents
he/she will take after, he was able to
mention significant factors such as food
and sleep for proper growth.

No.
I am not quite sure.

Stephen thinks that girls sometimes take
after their father and boys after their
mother. He cites himself as an example.
So he believes all children would be like
that, because by being boy one is already
like the father and he has to get some
qualities from the mother too, and this
would be height (short).

Eggs, meat and vegetables.

Marla postulated that boys are usually taller
than girls, so she would expect the boy to be
as tall as the father and the girl a little
shorter. She recognized foods as significant
factors to growth.

Foods - vegetables, meat.

Susan believes that the characteristics a
child acquire are a blend between the father
and the mother towards a mean. It is this
mean height which the child will get, be he
boy or girl.

Grade VI

QUESTION-RESPONSE TABLE

SAVI

			QUESTION I	QUESTION II	QUESTION III
			If a tall man and a short woman have a child: If the child is a boy, how tall will he be when he is fully grown?	If the child is a girl, how tall will she be when she is fully grown?	Why do you say so?
NAME	AGE	TOPIC			
Sarah	11.2	Relative contribution of a Parent = Man	Probably right in between the mother and the father. Because the mother and the father put in together, so it kind of balances in between them.	Probably be a little shorter than if it were a boy. But it will also be a mixing between the father and the mother.	Because the mother and the father put in together so it will be a kind of balance in between them
Richard	11.4		Do we have any definite height for this man? He will get the height from his father because his father is taller. He will get some other characteristic from his mother.	She would probably have the same height as her mother, and she might have the same eyes as her father or she might pick up something else from her father.	Because the father is tall and the mother is short. He might be as tall as the father. She might probably be as tall as the mother. This is not so all the times, but I guess most of the times.
Eric	11.10		I don't know but I think it will be the height of the father.	I believe she will be just anyhow. She maybe taller than her mother or shorter than her father. It could be a blend between the two parents but I am not positive.	I don't know why it will be the height of the father. I don't know, it could be the mother.
Gaelen	11.11		He will be tall. The boy comes from the father's side of it. The height is inherited from the father and the eyes from the mother.	Even if it is a girl, the height would still be from the father.	The height is inherited only from the father and other things from the mother.

Grade VI

QUESTION-RESPONSE TABLE

SAVI (cont'd.)

QUESTION IV

What other things do you think
would make a child grow tall?

COMMENTS

Good proteins, fruits,
love and attention.

Sarah sees none of the parents showing dominance over the other. She sees the child's characteristics as a balance between the two parents hence she predicts the child will be in between. Naturally the children should be in between but, she says, "but the girl should be smaller than the boy." She recognizes food as a factor.

I don't think so. I didn't
know (foods could help
growth)

The question of height inheritance to this boy is a tentative thing. Although many times boys grow tall like their father, and girl short as their mother, this trend could change once in a while. To Richard if the child acquires the height from one parent he would acquire some other feature from the other parent.

Yea, foods like meat, milk.

Eric says he is not positive about his predictions. And even these predictions he has merely couched on tentative premise. He does not believe the question of height either in boy or girl can be predicted with certainty.

Yea, foods could help growth.

Gaelen believes that only the father contributes to the height of a child, the mothers give other characteristics like eyes.

Grade VII

QUESTION-RESPONSE TABLE

SAVII

NAME	AGE	TOPIC	QUESTION I	QUESTION II	QUESTION III
			If a tall man and a short woman have a child: If the child is a boy, how tall will he be when he is fully grown?	If the child is a girl, how tall will she be when she is fully grown?	Why do you say so?
Tony	12.6	Relative contribution of a Parent = Height in Man	It depends on whom he takes after in size. He could be the size of his mother or the size of his father.	Same thing.	Usually it could be different size, he could take after his mother or take after his father.
Sergio	12.6		About the size of his Dad. Because usually sons are the same as Dads when they grow up.	The girl will grow up to be the same size as the size of the mum, probably; but she could be same size as her Dad, but usually is the mum.	Because usually sons are the same as Dads when they grow up. Usually she is like the size of her mum.
Sandra	12.8		I think he will be like his father. If he is a boy he is gonna be like his father.	She will be like her mother.	Boys take after their father, girls take after their mother.'
Liza	13.5		He would be tall. Well it is, like, his father is tall. The boy would take after his father. So he would be tall like his father.	I think she would be tall too because her brother is tall, but she will be shorter than her brother.	The father is tall and so children usually take after their father's heights. So the father gives more. The father does more active things and so he sleeps more, so he grows more than the mother who is mostly at home.

Grade VII

QUESTION-RESPONSE TABLE

SAVII (cont'd.)

QUESTION IV

What other things do you think
would make a child grow tall?

COMMENTS

Foods, good foods like milk,
celery and carrots.

Tony does believe that the height inheritance can be predicted on the bases of whether the child is a boy or a girl. He says it depends on whom the child takes after, it could be the mother or the father.

No, I don't know that.

Sergio is of the feeling that the sex of the child could be used to tell who of the two parents she/he could emulate in terms of height: The boy follows after the Dad, the girl after the mother. He notices no other variables at all.

No, nothing that I know of.

She believes boys take after their father and girls after their mothers.

Yes, food.

She thinks that the father gives more the inheritance of height in his children, but hence boys do more active things than their sisters, they get tired more and sleep more. To her the more you sleep the more you grow tall, hence boys are taller than their sisters.

Grade VIII

QUESTION-RESPONSE TABLE

SAVIII

NAME	AGE	TOPIC	QUESTION I	QUESTION II	QUESTION III
			If a tall man and a short woman have a child: If this child is a boy, how tall will he be when he is fully grown?	If the child is a girl, how tall will she be when she is fully grown?	Why is this so?
Vivian	13.00	Relative contribution of a Parent = Height in Man	Half way in between - Not as tall as his father but not as short as his mother.	She would also probably be a little bit taller than her mother, because I am.	The height of a child is a mix (blend) between the mother and the father.
Kelly	13.7		He will be tall, because his father is tall and most boys look tall.	She will be about medium. The girl will be a blend of her mother and father.	Because boys usually are tall and girls take after a blend of the mother and father.
Walter	13.8		He will be short like his mother; since he was born by the mother, he probably picks up some of the characteristics of the mother.	I think she will be short too. Both parents contribute to the child's characteristics but the mother gives more since she gives birth to the babies.	Well the mother is the one who gives birth to the babies, she will probably give more.
Mike	13.10		His father is big, so he is going to be big too. Sometimes the boy may just be the same as his mother. It depends.	Her mother is short, she will probably be short too. Sometimes too the girl will be like her father. It depends.	Because sometimes a boy is like his father, but he could also be like his mother; same thing for the girl. It depends.

Grade VIII

QUESTION-RESPONSE TABLE

5AVIII (cont'd.)

QUESTION IV

What other things do you think
would make a child grow tall?

COMMENTS

Their grandmother and grand-
father maybe tall so they may
be tall also after them.

Although Vivian thinks that the height
of a child is a blend between the mother
and the father, she was also able to note
that the tallness or shortness of a child is
dependent on the family history hence she
named the ancestors. She says, however, that
this trend could be altered by disease.

Foods, help one grow taller
and healthier.

Kelly is of the opinion that the
question of height in boys is not contro-
versal, boys usually are going to be tall,
girls, short. She recognizes anyway the
importance of food as a factor that could help.

The amount of food, protection
from disease.

Walter is of the opinion that children acquire
the height mostly from their mothers since the
mother is the birth giver. He is also able to
recognize other variables such as food as
contributors.

Food, what he eats. Exercise
too.

Mike cannot really predict for sure how the baby
will be when he/she is fully grown, it depends
on many variables, the parents, food, exercise, etc.