

An Investigation of the Effects of  
Conceptually Integrated Images on  
Prose Comprehension in High and  
Low Prior Knowledge Adults

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## ABSTRACT

AN INVESTIGATION OF THE EFFECTS OF CONCEPTUALLY INTEGRATED IMAGES

ON PROSE COMPREHENSION

IN HIGH AND LOW PRIOR KNOWLEDGE ADULTS

J. M. PICARD

Despite the recent proliferation of electronic media in education, a great deal of classroom instruction still centers on the printed textbook. It is debatable, however, whether the copious amount of illustrations found in textbooks directly contributes to greater learning and memory. This study examined the effects of two pictorial adjuncts on the learning of prose text. Additionally, the interaction between prior knowledge and the learning of illustrated and non-illustrated text were also examined. The subjects were 43 geography students (high prior knowledge) and 45 management students (low prior knowledge), who were randomly assigned to one of three experimental conditions: print alone; print + embedded pictures; print + adjacent picture. Following the treatments, all subjects were administered a free-recall and multiple-choice posttest. Two weeks later, subjects were retested with identical posttests.

A two-way analysis of variance on the multiple-choice dependent measures yielded no significant interactions between picture treatments and prior knowledge. Repeated measure analysis of variance on the free-recall dependent measures also revealed no interactions. There were, however, two main effects for treatment and prior knowledge.

Results from the study suggest that embedded pictures were more effective than prose alone or the adjacent pictorial adjunct on learning. In addition, embedded pictures facilitated learning for both high and low prior knowledge learners. Embedded pictures may have provided a more efficient schema evoking context for processing and retaining the passage content.

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## TABLE OF CONTENTS

	Page
Chapter 1: Introduction . . . . .	1
Text Books . . . . .	1
The Attentional Role of Illustration . . . . .	2
The Role of Illustration in Learning . . . . .	3
Pictures and Retention of Prose . . . . .	4
Pictures in Research . . . . .	5
Organization in Learning . . . . .	8
Individual Differences . . . . .	9
Statement of the Problem . . . . .	9
 Chapter 2: Literature Review . . . . .	 11
Early, Picture Research . . . . .	11
Picture Processing . . . . .	13
Picture Placement . . . . .	15
Prior Knowledge . . . . .	19
Organizational Images . . . . .	24
Verbal Ability . . . . .	28
Hypotheses . . . . .	28
 Chapter 3: Method . . . . .	 30
Prior Knowledge . . . . .	30
Experimental Design . . . . .	30
Instrumentation . . . . .	36
Multiple Choice Test . . . . .	36
Free-Recall . . . . .	37
Scoring the Free-Recall Protocols . . . . .	38
Measure of Reading Ability . . . . .	39
Interpolated Task . . . . .	39
Materials . . . . .	40
Prose Passage . . . . .	40
Illustrations . . . . .	40
Pilot Test . . . . .	43
Results . . . . .	43
Assemblage of Materials . . . . .	44
Procedure . . . . .	44
 Chapter 4: Results . . . . .	 46
Introduction . . . . .	46
Covariate Predictor: The Nelson Denny Reading Test . . . . .	46
Multiple Choice Posttest . . . . .	48
Immediate Multiple Choice Posttest . . . . .	48
Delayed Multiple Choice Posttest . . . . .	48

	Page
Knowledge and Comprehension Questions . . . . .	48
Free-Recall . . . . .	52
Post Hoc Analysis . . . . .	52
Conclusions . . . . .	56
 Chapter 5: Discussion . . . . .	 57
Pictorial Effects on Learning from Prose . . . . .	57
Differences in Prior Knowledge . . . . .	60
Prior Knowledge and Learning from Illustrated Text . . . . .	60
The Retentional Benefits of Illustrations . . . . .	64
Conclusions and Implications . . . . .	66
 Reference Notes . . . . .	 69
 References . . . . .	 70
 Appendices . . . . .	 77
Appendix A. General Instructions . . . . .	78
Appendix B. Conceptually Integrated Condition . . . . .	80
Appendix C. Embedded Picture Condition . . . . .	91
Appendix D. Control . . . . .	104
Appendix E. Multiple-Choice Test . . . . .	114
Appendix F. Free-Recall Test . . . . .	126
Appendix G. Idea Units . . . . .	128
Appendix H. Interpolated Task . . . . .	137

List of Tables

	Page
Table 1. Means and Standard Deviations of the Experimental Sample: Age . . . . .	31
Table 2. Absolute and Relative Frequencies for Sex of High and Low Prior Knowledge Subjects. . . . .	32
Table 3. Absolute and Relative Frequencies on a Self-Reported "What is Your Major" Question. . . . .	33
Table 4. Means and Standard Deviations of the Total Sample on the Nelson Denny Reading Test. . . . .	47
Table 5. Means and Standard Deviations for Experimental Groups on Immediate and Delayed Multiple-choice posttest. . . . .	49
Table 6. Analysis of Variance Summary Table for Immediate 20-item Multiple Choice Posttest. . . . .	50
Table 7. Analysis of Variance Summary Table for Delayed 25-item Multiple Choice Posttest. . . . .	51
Table 8. Means and Standard Deviations for Experimental Groups on Immediate and Delayed Free Recall Dependent Measure . . . . .	53
Table 9. Analysis of Variance with Repeated Measures for Free-Recall Posttest . . . . .	54
Table 10. Absolute and Relative Frequencies on a Self-Reported "Familiarity with Passage Content" Question . . . . .	63

List of Figures

	Page
Figure 1. The experimental design . . . . .	35
Figure 2. Sample from the embedded picture treatment . . . . .	42
Figure 3. Comparison of free-recall means across treatment conditions . . . . .	55

## Chapter 1

### Introduction

#### Textbooks

In the last ten years, an interest in studying processes which enhance prose learning has been growing among educational technologists. The current popularity of prose enhancing techniques (e.g. advance organizers, questioning strategies etc.) may be partly explained by diminishing financial resources available to educators. Consequently, there has been a growing concern for updating and improving existing resources which will increase learning without proportionately increasing cost. Textbooks and other printed instructional materials still remain an important source of learning. As an instructional medium, textbooks are able to carry both verbal and visual information. Additionally, the quantity of information which is processed from text is left largely up to the learner; therefore one might say that textbooks provide self-paced instruction.

Given that textbooks play an important role in instruction, it is of paramount importance that greater care and attention be placed on the design of text. According to Reigeluth and Sari (1980), producing quality textbooks is a fundamental consideration since the quality of text and other print materials has a far reaching impact on the appeal, effectiveness and efficiency of education. Whether this impact has a positive or negative effect depends largely on the ability of instructional designers to adopt, modify and re-examine adjunct aids in order to determine their relevancy in the learning process. One instructional adjunct which is currently attracting



attention is the use of illustrations.

### The Attentional Role of Illustrations

The inclusion of illustrations and other graphic images in prose is an instructional practice with which almost all learners and instructional designers are familiar. The practice of using pictures to illustrate text goes as far back as the early fifteenth century. For example, in Europe during 1472, Valturius used printed pictures from woodcuts to illustrate his 'Art of War' which dealt with the building and operation of various war machines (Olson, 1974).

Today nearly all instructional textbooks used in education are noted for their frequent use of illustrated material. Despite the longstanding popularity of pictures as adjuncts to printed text, it remains unclear whether pictures contribute anything other than 'package appeal' to learning. The argument for pictures as motivational aids or as agents in influencing attitudes has been noted by Samuels (1970) and Vernon (1953). Concannon (1975) points out that the attentional role of illustrations is readily acknowledged for younger learners, but she speculates as to whether pictures are justified at a later age. The main consensus of studies by Vernon and supported by Concannon, was that pictures do heighten interest in the material being studied, but are of questionable use as memory or comprehension aids. A similar argument was raised by Baker & Popham (1965) in a study involving older learners. Humorous cartoons were used to illustrate a slide tape programme intended for teaching education students about behavioral objectives. The results showed that the students who viewed the embellished programme were more favorably disposed towards the subject matter. However, as predicted, these students performed

no better on their knowledge of behavioral objectives than the control group. The authors concluded that illustrations did improve attitudes and motivation; however, they questioned whether this advantage justified the added cost.

Including illustrations and graphic images as prose adjuncts adds substantially to the cost of instructional texts. With cost-effectiveness as an important criterion in media selection (Jonassen, 1980), it is obvious that aside from their motivational and attentional roles, pictures must assume more of a cognitive burden in the learning process.

#### The Role of Illustrations in Learning

In an attempt to clarify the role of pictures included in textual materials, Duchastel (1978, 1980) has argued for a functional approach to defining picture-prose relationships. He cites three roles of illustrations in text; attentional, explicative and retentional. Discussed earlier, illustrations fulfilling an attentional role motivate the learner by attracting and sustaining interest. Of particular importance to instructional designers however, are the explicative and retentional roles of illustrations. The primary function of the explicative role is to explain abstract verbal information in pictorial form. Therefore, explicative images should facilitate the comprehension of prose text. Illustrations fulfilling a retentional role assist in the long term retention of verbal information by providing the learner with a conceptual plan of the main points of the subject matter. Accordingly, these main points are more easily retrieved from memory at the time of recall since remembering the picture provides cues to remembering the prose. Duchastel (Note 1) offers some empirical

evidence to support the long-term benefits associated with retentional images. Using an illustrated versus non-illustrated history passage, fifteen year-olds were tested immediately after reading a passage, and two weeks later. As predicted, there were no differences on the immediate test. However, two weeks later, there were significant differences on the cued free recall test. Not only did the pictures facilitate the learning of 'illustrated' passage content, but it was found that the retentional images also improved the learning of non-illustrated verbal material. Duchastel explained that although the pictures functioned as retentional aids, they may also have functioned as motivational aids. This supports the notion that the three picture functions are not mutually exclusive and perhaps there is more to a given illustration than meets the eye.

In conclusion, if illustrations are able to provide more than a motivational role in learning, then this facilitative effect of pictures on learning warrants a closer examination. It would be unfortunate to discard such an intuitively obvious instructional aid to learning, particularly if pictures are able to facilitate long-term retention of prose.

#### Pictures and Retention of Prose

While picture studies have not typically addressed the issue of long term retention, there are a few studies which have shown that pictures in text can facilitate long-term memory of prose content (Haring & Fry, 1979). Peeck (1974) is often credited for his insight in studying the retentive effects of pictures over time. It would seem that memory performance is better with pictures than with their verbal counterparts especially when retention is measured at delayed

intervals. Support for such a view is based on Paivio's Dual-Coding Hypothesis (Paivio, 1971). Paivio considers cognitive processing to consist of two distinct but interconnected verbal and imaginal systems. Pictures are typically coded in memory both verbally and imaginally, whereas abstract words are coded only verbally. Since there is a redundancy of visual and verbal coding, pictorial information is remembered better (i.e. it is more easily retrieved from long-term memory).

In a recent study, Bernard, Peterson and Ally (1981) found no immediate effect with a verbal and pictorial organizer versus no organizer, but on a delayed test (two weeks later) differences were found between the organizers and the control groups. The results of this study support the durability of pictorial supports in long-term memory.

In conclusion, while a considerable amount of picture research exists, those studies which have addressed the enduring qualities of pictorial supports have been the exception rather than the rule. Therefore, the current study examined the retentional effects of images over two time-intervals.

#### Pictures in Research

There is still inconclusive support for illustrations as adjunct aids in facilitating prose comprehension and memory. Part of the problem stems from the wide diversity of pictures as research variables which differ along many dimensions including size, artwork and pictorial content (Willows, Note 2). Therefore it is not surprising that over the years, picture research has been in such a confused state that few guidelines are available to the instructional designer. Consequently, there is the

danger that the selection and design of pictorial aids will be left largely to the intuitive whims of the graphic artist (Duchastel, 1978).

For example, commercial textbooks aimed at children are noted for their plethora of brightly coloured and complexly designed pictures. Although a study by Myatt and Carter (1979) has shown that readers prefer colourful realistic pictorial embellishments, Dwyer (1978) has also pointed out that picture preference is not a valid indicator of better learning gains. Indeed, there is some research evidence supporting the facilitative effects of visually sparse line drawings (Haring and Fry, 1979). Yet in examining the use of line drawings as research variables, both Brody (1981) and Willows (Note 2) have criticized the simplicity of these illustrations and their overuse. Brody (1981) has argued that in order for picture research to be meaningful, and therefore relevant to the instructional designer, it should more closely reflect the complex visual arrays typically found in textbooks.

Other common research methodologies are also of interest. Frequently, research designs employ a comparison between a treatment group which receives an illustrated passage, and a group which receives a non-illustrated passage. The employment of the picture/no-picture paradigm results in a tendency to treat illustrations as composite wholes (Brody, 1981). However, pictures are also composed of various elements which should be isolated and compared in order to better determine the relationships which might exist between the images and the text. Denburg (1976-1977) insightfully points out that it is not enough to know that illustrations enhance learning; of greater importance is how illustrations play a role in providing greater learning gains and why this occurs.

Another concern with studies which have addressed the relation-

ship between picture types are the quantitative differences in semantic content contained in the illustrations. Brody and Legenza (1980) for example, investigated the influence of two types of pictures and their location on prose learning. The authors concluded that although picture type was not significant, one of the pictures, an overview, provided greater learning gains than the illustration which depicted a specific scene from the passage. It seems plausible to suggest that given the greater amount of semantic content contained in the overview, it is surprising that this picture treatment did not perform differently than the no-picture condition. Therefore, if comparisons are to be made between various types of illustrations, care should be taken to include the same amount of information in each picture treatment.

A final characteristic of many verbal learning studies is the inappropriate passage lengths which are employed (Brody, 1981). According to Salomon (1979) studying small segments of discourse requires far less mental elaboration than the comprehension of a two thousand word text, all other things being equal. Therefore, generalizations between a two hundred word verbal treatment and a passage of the length typically employed in educational practice can only be tenuous at best.

The study reported here was designed to address the retentional function of images as outlined by Duchastel (1980). In addition, Brody's (1981) assertion for more complex visual arrays and longer prose passage were addressed in the design of the prose and pictorial materials. Brody has argued that pictures should not be treated as isolated variables; therefore, the present study was designed to explore further the relationships between two pictorial adjuncts on prose learning.

### Organization in Learning

The effective use of summaries and outlines has been established by several investigators (Glynn & DiVesta, 1977; Hartley & Trueman, 1981). Outlines, for example function as organizational adjuncts by providing a preview of the passage content and informing the learner as to the nature and the sequence of the content (Staley & Wolf, Note 3).

According to Shimmerlik (1978) the primary role of organization in memory is that it provides the learner with an intact retrieval schema. Schema is defined by Kintsch (1977) as consisting of an organized representation of an individuals' knowledge concerning a concept, action or event. This retrieval schema is formed during the encoding process and consists of associated units or chunks of information. During recall, retrieval cues from the schema activate other relevant cues thereby facilitating recall of more specific passage related information.

While an impressive body of organizational research exists (see Shimmerlik, 1978), Staley & Wolf (Note 3) point out that this research has been primarily concerned with either varying the organizational structure of passage content or manipulating the learners' knowledge of the content (typically by varying the location of organizational aids). To date, there is little research which has examined the relationship between the organization of illustrated concepts on the learning of prose (Stone, Pine, Breger & Glock, Note 4). The organization of pictorial adjuncts is an important variable to consider in picture-prose research. This is in keeping with Dwyers' (1978) suggestion that more research is needed in order to determine what combinations of visuals are most effective in prose learning.

Individual Differences

Individual differences in prior knowledge have been found to affect how learners profit from different types of visuals while learning. For example, Dwyer (1975) found that while realistic coloured photographs facilitated learning and comprehension in high prior knowledge subjects, those in middle and low prior knowledge groups did considerably worse.

While researchers generally agree that factors other than colour influence learning (Fleming, 1979), few studies to date (i.e. Weisberg, 1970) have examined the role that prior knowledge plays in picture-prose learning. While there has been a growing concern for individual differences in learning (c.f. Cronbach & Snow, 1977) the status of prior knowledge has assumed an ancillary role in research; a factor to be controlled, rather than as a pertinent variable in its own right (Schmid, 1977). Recently, Reder (1980) in examining the use of verbal adjuncts in prose learning has stated:

'The apparent inconsistency in results among some of this research probably stems from our inadequate understanding of the structure of passages, how content is represented and how it is processed and integrated with prior knowledge' (p.11).

In conclusion, since prior knowledge plays such an important role in prose processing, and considering the negligible treatment of prior knowledge in picture research, the present study was designed to explore further the relationship between prior knowledge and the use of pictorial adjuncts.

Statement of the Problem

For the purposes of this study, three questions related to the implications of pictures in instructional text were posed:



1. What effect does the organization of pictorial adjuncts have on memory and comprehension?
2. What role does prior knowledge play in learning from illustrated and non-illustrated text?
3. What effect will pictures have on memory over time?

## Chapter 2

### Literature Review

#### Early Picture Research

To date, research examining the effects of pictures on reading has been far more extensive in respect to children than it has been with older learners. Such studies have frequently reported contradictory results. Along with studies that have shown a facilitative effect on learning (i.e. Peeck, 1974; Rohwer & Harris, 1975; Haring & Fry, 1979) there are many others which have not (i.e. Vernon, 1953; Weintraub, 1960; Gellner, Note 5). Part of the confusion surrounding pictorial effectiveness stems from early picture research. The most frequent question asked in early research, (1930's - 1960's) was whether the pictures found in basal readers enhanced or interfered with childrens' comprehension of prose. Several examples are cited below along with their findings. Miller (1938) reported no differences in childrens' comprehension scores between an illustrated basal primer and a non-illustrated primer. Vernon (1953, 1954) in a series of experiments found that illustrated text did no better in improving childrens' comprehension than non-illustrated text.

Weintraub (1960) examined the effects of illustrated basal readers on children of high and low reading ability. He found that comprehension was greater for low ability students who did not receive pictures. Weintraub's findings that pictures might interfere with learning for low ability children was also supported in a study by Samuels (1967). In his concluding remarks, Samuels (1967) questioned the instructional value of including illustrations in reading primers. Later, in a review of the literature, Samuels (1970) concluded that when used as adjuncts to text, pictures not only interfered with learning to read, they also had no

effect on comprehension.

There is, however, some doubt as to the rigorousness of these early studies, some of which were included in Samuel's review. For example, Holliday (1973) questioned the validity of Vernon's (1953) results based on the authors methodology and the vague descriptions of the pictorial stimuli used in Vernon's study. Denburg (1976-1977) has criticized Samuels (1967) for not allowing the children in the picture group enough time to take advantage of the pictures. Therefore, the design might have favored a no-difference finding.

Schallert (1980) has argued that the types of illustrations used in some of the early basal studies were not originally intended to fulfill a retentional or explicative role in learning. Therefore, it is not too surprising that pictures showed no facilitative effects on comprehension.

Based upon current conceptualizations, it appears that Samuel's (1970) conclusions were somewhat premature. More recently, Levin & Lesgold (1978) have asserted that '...there is solid evidence that pictures facilitate prose learning' (p. 233). In providing evidence for this, the authors found consistent learning gains attributable to pictures as long as prose passages were presented orally; passages were fictional narratives; pictures overlapped the story content; and learning was demonstrated by factual recall.

While these guidelines are invaluable in providing an analytical framework for research, they are rather limited in applicability for the instructional designer. For one thing, instruction and communication aimed at children and older learners is largely based on the language of formalized written prose (Olson, 1977). Often, instructional prose is non-fictional rather than fictional, and written in an expository form. Unlike the passages described by Levin & Lesgold (1978), such materials may be

relatively abstract in nature and may have a high information density. Furthermore, factual recall assesses only one level of learning; students in an instructional situation are often expected to achieve higher learning outcomes.

Therefore, the evidence supporting pictures in prose which currently exists still lacks specific guidelines and principles (Dwyer, 1978; Fleming, 1979), particularly as it applies to more mature learners. As for the contribution of Levin and Lesgold's (1978) ground-rules, even they admitted that due to age - related differences in cognitive development, pictorial strategies which are effective for children cannot necessarily be generalized to adults.

#### Picture Processing

In early pictorial research, pictures were often used as stimulus items in paired-associate learning. Numerous studies demonstrated that visual stimuli were superior to verbal stimuli when subjects were tested for recognition (Shepard, 1967; Snodgrass, Volvovitz and Walfish, 1972). Standing, Conezio and Haber (1970) found that subjects were able to correctly identify roughly 85 to 95 percent of 2,560 slides which were presented to subjects over a four day period.

These impressive results associated with visual memory spurred a resurgence of interest in non-verbal memory processing (Levie, 1973). Research on the independence of verbal and pictorial memory in adults was addressed by Levie and Levie (1975). They found that verbal and pictorial information was processed independently in memory with the results favoring picture memory when subjects were tested for both recognition and free-recall. Moreover, it was discovered that if memory tasks required a verbal response, then subjects had a tendency to covertly label the

pictorial information verbally. Levie and Levie concluded that verbal and pictorial information were processed independently in memory when subjects were tested for recognition. In addition, the verbal and pictorial memory systems were highly interconnected particularly when subjects anticipated that a verbal response was required. These conclusions provide support for the Dual Coding Hypothesis (Paivio, 1971) suggesting that information is processed by two separate imaginal and verbal memory systems. Both systems are functionally independent i.e., either system is specialized for processing certain types of information, and both are interconnected such that either can operate in conjunction with one another.

As predicted by the dual coding model, pictures are more easily remembered than concrete words, whereas concrete words are better retained than abstract words. This rationale is based on the assumption that concrete words can be measured for their power of evoking a corresponding mental image of the word. If the learner is able to generate his or her own mental image while reading, then the verbal information is processed in both imaginal and verbal memory. This suggests that concrete prose might not benefit from the inclusion of ready-made illustrations (Royer and Cable, 1976) since learners may be able to covertly generate their own internal representation of the content. If on the other hand, the prose does not provide concrete referents or if for some other reason the learner cannot generate a mental picture, pictures may effectively supplant that deficit (Salomon, 1974, 1979). In addition, pictures may arouse mathemagenic activity (Rothkopf, 1970) in the learner. The following selection from Salomon (1974) specifies how that might occur:

'First, they [media] arouse certain general attentional processes. Without the arousal of attention and some mathemagenic responses, no effective communication can take place at all...particular

modes of presentation arouse typical mental processes such as comparisons, analysis, relating, and the like. The activation of such processes facilitates the extraction of the intended messages' (p. 401).

Second, pictorial media with its' variety of symbolic codes may activate various kinds of mediational activity. For instance, the symbolic codes employed by maps, photographs and Knowlton's (1966) logical pictures such as diagrams may also activate or supplant deficient mental skills in the learner (Levie, 1978). For example, if the learner is unable to generate an internal visual representation of a concept (thereby ensuring a better memory trace), then a ready-made picture might provide an internal elaboration and make it easier for the learner to process the information. According to Salomon (1972) a supplanting function is a covert cognitive process which may be assimilated into the learners' schema. As a result, the learners' schema is either modified, or through the supplanting function, supplied with a new schema.

Accordingly, it was assumed that the two picture treatments used in the current study would facilitate a supplanting function in learners who lack the necessary cognitive structure. This assumption will be dealt with in more detail in the section on prior knowledge.

#### Picture Placement

It has become increasingly obvious in prose learning that the location of verbal adjuncts i.e. adjunct questions (Watts & Anderson, 1974), advance organizers (Ausubel, 1960), outlines (Glynn & DiVesta, 1977), in relation to the instructional prose, plays an important role in learning and the cognition strategies the student makes use of during learning. Rothkopf (1970) for instance, found that post questions produced a greater overall effect on learning than questions which were presented before the

relevant prose. Pictures as adjuncts may also have a similar effect on learning. For example, Snowman and Cunningham (1975) had college students read a lengthy passage which contained either questions, or student generated pictures, and questions plus pictures before and after each paragraph. Results indicated that student-generated pictures were equally effective in facilitating learning as the verbal questions in the post-passage condition. The location of pictures and picture types were also examined in a later study by Brody and Legenza (1980). In this study, experimenter-provided pictures were placed before or after a prose passage. Two types of pictures were used. One picture provided a broad overview of the verbal content (a market square), while the second picture depicted a specific incident which occurred in the passage (a snake charmer). The results favored the post picture location, similar to those in Snowman and Cunningham's study (1975).

While mathamagenic applications within the picture prose literature have generally favored post-passage placement, other studies have reported facilitative effects when the picture is placed in advance of the passage. The assumption of these studies is that pictures can provide contextual support for the passage in learners who do not possess requisite prior knowledge. A recent study by Bernard, Peterson & Ally (1981) compared the effects of verbal and pictorial contextual organizers on memory for passage content. The immediate post-test revealed no differences between the control and the two organizers. On the two week delayed posttest, both verbal and pictorial organizers performed significantly better than the control groups. However, there were no significant differences between the verbal and the pictorial organizers.

Similarly, a study by Bransford and Johnson (1972) demonstrated the facilitative effects of pictures used in advance of the passage when

contextual support is absent. Subjects were given an ambiguous passage with either an appropriate or inappropriate picture or title presented before the passage or after the passage. The authors found that comprehension and memory of a prose passage were greatly improved when the subjects were given the appropriate picture in advance. They concluded that without such referents, subjects were unable to activate the relevant memory schema and consequently were unable to comprehend or remember the passage.

The pictures used in the preceding studies were designed to fulfill what Levin (Note 6) calls the 'interpretive role' of pictures in prose learning. The interpretive image is one function of pictures which is designed to clarify complex prose material so that the content becomes more comprehensible. Presumably, pictorial adjuncts of this type, when used in conjunction with prose, facilitate the activation of relevant schema by relating the information to existing knowledge (Levin and Pressley, Note 7).

Another example of illustrations fulfilling an interpretive role is reported in a study by Royer and Cable (1975). College students were given an initial concrete or abstract passage with illustrations or verbal analogies embedded in the passage. After reading the experimental passage, all groups received a second abstract passage similar in subject matter. The results showed that there was a significant increase in comprehension gains for the group which received illustrations or analogies in the abstract passage. In concluding their analysis, Royer and Cable suggested that the illustrations helped the learner relate the new information to his/her existing schema. Therefore, pictures helped clarify the relatively abstract concepts by providing a picture context; an interpretative framework (Dean & Kulhavy, 1981); an assimilative structure (Schallert, 1980); for



comprehending difficult-to-understand prose.

The general question as to where pictures should be placed in order to optimize learning still remains unresolved. It seems to revolve around the nature of the content and the learners' prior familiarity with the content. If the learner can be assumed to possess sufficient prior knowledge, then a picture in the post passage condition may stimulate rehearsal and additional processing of the content. In the Brody and Legenza (1980) and the Snowman and Cunningham (1975) studies, the content of the passages was relatively general (i.e. a fictitious tribe and a market square, respectively) and concrete (i.e. describing a place). However, when prior knowledge was manipulated so that subjects were not in possession of contextual support in advance (Bernard *et al.* 1981; Bransford & Johnson, 1972; Royer and Cable, 1975) pre-pictures were found to provide greater overall learning gains.

Researchers generally agree that the location of adjuncts, whether verbal or visual, has potential for manipulating how information is encoded and processed in learning (Brody and Legenza, 1980). In support of this, Hartley (1979) has advocated that learning from illustrated text may be greatly influenced depending on where the illustrations are placed in the passage. Although there is little research available which supports the use of embedded images (i.e., Peck, 1974; Haring and Fry, 1975) there is reason to believe that careful arrangement of images (Weintraub 1960), taking into consideration the prior knowledge of the learner and the nature of the prose, might facilitate enhanced learning. In conclusion, if pictures are designed to provide an interpretive framework for understanding abstract discourse, then the optimal placement of the images should be before the relevant paragraph or passage.

This is in keeping with Bransford and Johnson's (1972) findings that the inclusion of an image after a paragraph had little or no effect on activating the relevant schema in the learner. Although the learner may initially possess prerequisite knowledge, unless a schema-evoking context is provided (Bransford & Johnson, 1973) information may not be retained in memory. As Bransford and Johnson point out, contexts may also be verbal; illustrations, however, are able to provide a visual frame of reference which appears to be better retained in memory.

#### Prior Knowledge.

Despite the acknowledged importance of prior knowledge in prose processing, it has received only partial research attention in the last fifteen years (Schmid, 1977). Currently, the research that does exist strongly suggests that the amount of knowledge a person possesses is predictive of how well a person will process and comprehend new information (Bransford & Johnson, 1972; Levin & Pressley, Note 7). This suggests that one of the most important things that readers bring to a prose test is their prior knowledge (Anderson et. al, 1977). Why is prior knowledge considered such an important variable in prose processing? Bransford and Johnson (1972) have demonstrated that prose processing is not an isolated function, rather it is an orchestration of prior knowledge interacting with new incoming information. As Alverman explains: "This interaction between information found on the printed page and a reader's previous knowledge is the essence of a schema-based theory of comprehension" (Alverman, Note 8, p. 4). Rumelhart and Ortony (1977) consider schema a key element in explaining how a reader comprehends verbal information. It is essentially a process of bringing together appropriate schema in order to interpret

the new information. An individual's interpretations consist of elaborate 'instantiations' of schemata. According to Anderson (1980), instantiated schemata consist of a copy of the schema which were activated in interpreting some sort of sensory data, whether visual or verbal information, plus the new information which was inserted into these subschema. Therefore, in understanding prose:

'Clues from the story suggest possible interpretations (instantiations of schemata) that are then evaluated against the successive sentences of the story until finally a consistent interpretation is discovered' (Rumelhart, 1980, p. 47).

Anderson (1980) believes that the greater the prior knowledge of an individual, the more elaborate the schemata that can be called into play, and therefore the greater the learning. He argues that:

'...the task for the advanced student is simply to fill the slots in an already formed schema with the particular information in the text. ...The information will be readily acquired and, once acquired, easily retrieved when needed' (p. 37).

Accordingly, individuals with low prior knowledge in a particular subject area will not possess these elaborate schema. There is, however, some evidence (Anderson, 1980; Anderson, Reynolds, Schallert and Goetz, 1977) that people possess high level schemata or general knowledge which they bring to the learning task. The provision of a pictorial adjunct with the passage may therefore more readily evoke existing schema in the learner or facilitate the creation of schema in order to aid in the interpretation and processing of new information.

These ideas are consistent with Ausubel's theory of advance organizers (Ausubel, 1960, 1968). Ausubel has long recognized the influence that prior knowledge may have on prose learning. New information is remembered more efficiently if the learner already possesses a cognitive structure which serves as an 'ideational anchorage' for

incoming information. Optimally, ideational anchorage insures that the otherwise temporal nature of new verbal information will be retained longer in memory (Ausubel, 1978). A study on advance organizers by Weisberg (1970) is one of the few to examine the effects of prior knowledge in learning from illustrated text. In controlling for high, medium and low prior knowledge, Weisberg (1970) manipulated a verbal organizer and two types of visual organizers, a graph and a map, on the learning of science concepts. Significant results were found for all levels of prior knowledge on the two visual organizers in comparison with the verbal organizer and the control group. The results from this study suggest that prior knowledge may influence the relative effectiveness of pictorial and verbal adjuncts (Weisberg, 1970).

According to Dwyer (1978) individual differences in prior knowledge may also determine whether or not pictorial adjuncts are necessary in facilitating prose learning. He cites Bruner (1957) in pointing out that learners who possess high prior knowledge do not necessarily benefit from illustrated text. In fact, Dwyer (1978) remarks that the familiarity of stimulus material is a function of the prior knowledge an individual possesses. Accordingly, the greater the prior knowledge the more concrete the subject matter is to the learner and conversely, the lower the prior knowledge, the more abstract the material. In the Royer and Cable (1976) study, the authors found that an initial concrete passage or an illustrated abstract passage both served the same function. In other words, they equally facilitated the creation of a knowledge structure in the learner which subsequently made the second abstract passage easier to learn and remember. It should follow then, that learners with sufficient prerequisite knowledge already possess an elaborate knowledge structure (i.e. an otherwise abstract passage is made more concrete) and therefore might not

benefit from illustrations. However, low prior knowledge learners who do not possess cognitive building blocks or elaborate schema may require illustrations in order to create new cognitive structures or provide concrete 'instantiations' for an existing but poorly elaborated schema. For instance, a learner might know certain terminology in a subject area (e.g. the physics term "relativity") but have little notion as to the meaning of that terminology or how it interconnects with other terms (or concepts) in the subject matter. Illustrations may help this learner logically interconnect concepts while also providing meaning.

Salomon (1979) has also argued that if learners possess a large body of prior knowledge, then new information pertaining to the learners' prior knowledge is easily assimilated into their cognitive structure. However, the meaning extracted from information which is totally new or novel is highly dependent on the symbol system which is used. Meaning in this case is defined as the information or ideas which are intended by the author in order for comprehension to occur (Rumelhart, 1980). According to Salomon, high prior knowledge learners may extract the same meaning from illustrated text, or print alone. If the information is novel, however, and learners do not possess prior knowledge, then new cognitive structures may need to be developed. The creation of these structures for processing and retaining the information may depend upon the symbol systems used to instruct the learner. That is, the learners' new schema may be specific to the symbol system employed in initial learning. For instance, a learner trained in the use of statistical notation may not initially see the relationship between a particular equation and a graphic representation of that equation. Learning has been specific to a particular scheme of symbolic representation. Subsequent learning using varied but interrelated symbolic forms will

provide a more generalized conception of the content which is not dependent upon a particular notational scheme or representational form.

Salomon (1974) claims that covert mental skills may be differentially affected by the dense symbol system that an illustration provides (i.e. compared with words). He goes on to say that:

'Similar differences of effect occur as a result of varying the spatial arrangements of visual presentation. Putting two visual displays side by side tends to activate comparison and discrimination. The information picked up in such a case is quite different from that gathered when the visuals are presented successively' (p. 389).

The acquisition of knowledge from such simultaneous visual displays, however, depends upon the learners' prior knowledge. In the case of high prior knowledge learners, such a complex display may readily supplant mental skills, since it may be more representative of how the learner would process the information internally. In other words, the learner who possesses elaborate schema would be able to make comparisons between various concepts. In contrast, the low prior knowledge learner, lacking the appropriate knowledge structures may find such a presentation too novel and therefore might not benefit from a complex visual array.

In conclusion, differences in prior knowledge may play a determining role in whether information should be presented verbally or pictorially. The combination of two symbol systems such as illustrated text offers more options to the learner with low prior knowledge in extracting the correct meaning of an intended message. If visuals are used to supplant certain mental activity, then the way the visual information is presented may supplant certain mental processes as long as it is compatible with the learner's own internal representation.

### Organizational Images

It has been found in prose research that providing the learner with information concerning the organization of the passage content improves learning (Shimmerlik, 1978; Alverman, Note 8). Alverman (1981) for instance, found that learning was facilitated when less-than-optimally organized text was preceded by a graphic organizer designed to show the relationships between major concepts. Similarly, the organizing function of picture-word diagrams have met some degree of success in the learning of science concepts (for a review, see Winn and Holliday Note 9).

There have also been attempts to use pictures as organizational aids, particularly with regard to mental imagery in childrens' learning of oral discourse. For example, Ruch and Levin (1977) presented children with partial pictures (pictures which contained most but not all important information found in a short text) during or after the presentation of prose sentences. The results indicated that the pictures presented with the prose facilitated recall of paraphrased questions. The authors concluded that illustrations provided the learner with a more efficient organizational device which the learner used to imaginably insert new information. These illustrations, according to Ruch and Levin (1977), provide a stage-setting function. Pictures tell the learner in advance what the passage is about, and sensitize him to the structure of the content to be learned by providing a frame of reference for organizing the prose material (Levin & Pressley, Note 7).

In addition, the placement of verbal labels in map-like illustrations may play a determining role in how well people remember text-related information. Schwartz and Kulhavy (1981) for example, manipulated the location of verbal labels in two map-like illustrations. In one condition, the verbal labels were embedded in the map, while in the

second condition, the verbal labels were simply listed to one side. The control condition consisted of a map with no labels. The results favored the map with the embedded verbal labels. The authors concluded that since the spatial arrangement of the verbal labels in the map were meaningfully related to the accompanying prose passage, the learner was able to use the illustration as an organizing framework for storing information from the prose passage. This suggests that illustrations may provide the learner with a spatially organized structure which he or she is able to internalize and later call upon when needed (Schallert, 1980). Dean & Kulhavy (1981) also demonstrated that the organizing properties of a map-like representation provide the learner with a cognitive device for storing large amounts of related textual information. These organizing properties were also found to improve comprehension.

Reynolds (1966) found that the integration of verbal and pictorial stimuli into a single spatial structure greatly improved verbal recall. Subjects in the study were required to learn sentences which contained nonsense words of three letters in length. Prior to receiving sentences, subjects were assigned to one of three groups. One group received the letter combinations embedded in a map-like illustration; the second group received discrete segments of the same illustration which were randomly arranged while the control group received only a list of the nonsense words. The results indicated that prior exposure to a map-like illustration provided the learner with an organized and integrated perceptual structure which subsequently improved verbal recall. On the basis of the data, Reynolds (1966) concluded that the superior learning demonstrated by the integrated picture group was primarily due to the organizational function of the image. In a second



investigation using the same two-stage transfer paradigm, Reynolds (1968) sought to determine whether the positive effects of the integrated map-like illustration would be consistent with different materials; a younger age group; and over a longer interval. Again, the results indicated that the integrated picture group out-performed the non-integrated and control group. The study also corroborated the findings of Schwartz and Kulhavy (1981) that merely including verbal and pictorial material in an illustration is not enough to guarantee learning gains. What is deemed important is the way the elements or concepts are organized and integrated into a single structure.

In a closely related study (Spangenberg, 1971), similar conclusions were reached. Spangenberg varied three levels of pictorial coherence; minimal, subgrouped and overall structural displays. Structural display was operationally defined as the degree to which elements appear to be integrated in a single illustration. The results indicated that the realistic overall map display produced greater learning than the subgrouped or minimal displays. Similar to Reynolds, Spangenberg concluded that pictures provided the learner with a more stable organizational schema than their verbal counterparts.

A study by Main & Griffiths (1977) applied these findings to the learning of complex, conceptual relationships similar to the subject matter used in the current study. Using expository prose which is more characteristic of textbooks used in instruction, subjects were given either a prose passage to read or they listened to an audio tape complemented with either a print or pictorial supplement. The pictorial supplement was designed to show an overall structural coherence based on Spangenberg's (1971) pictorial display. The results favored the groups which received either the pictorial or the verbal supplements in com-

parison with the print only group. They concluded that the gains from the pictorial and verbal supplements were mainly attributed to the organization of the concepts into a logically ordered presentation.

In summary, previous research findings have demonstrated that various types of illustrations may function as an organizational aid in prose learning. In some cases, these images are able to show both conceptual and spatial relationships between concepts and provide a frame of reference for interpreting new information. Moreover, organizational adjuncts provide the learner with an organized schematic representation of the passage content. Accordingly, if the learner is aware of the organization of the content in advance, then memory and comprehension is facilitated (Alvermann, Note 8). The degree to which pictorial elements are spatially integrated in an illustration have also been shown to provide greater learning gains (Reynolds, 1966, 1968; Spangenberg, 1971). According to Spangenberg:

'The perceptual feature of showing the interrelatedness of each item to the whole seems to enhance the quality of learning' (p. 519).

Based on the preceding arguments, the current study was designed to address the effects of a single conceptually integrated image on prose learning. This image consisted of a visual summary of key concepts which were taken from the main passage. Since the structural relationships between the concepts were relatively complex, and not given to a realistic display, the design of the illustration portrayed a conceptual spatial organization rather than a realistic spatial organization. However, the importance of showing the interrelatedness of these concepts (Spangenberg, 1971) was also taken into consideration. It was predicted that the conceptually integrated image, operationalized

here as a logically organized concept structure, would better facilitate the organization of the passage content by providing a more integrated structure than its pictorial counterpart: the embedded picture condition.

### Verbal Ability

Although the relationship between verbal ability and learning from text is well established (Winn & Holliday, Note 9), it is often overlooked in picture-prose research. In a recent picture study (Gellner, Note 3), reading ability was responsible for the largest variance in a population of young adults. For this reason, the Nelson-Denny Reading Test (Nelson & Denny, 1973) was intended to be treated in the study as a co-variate in the statistical analysis.

### Hypotheses

This study examined the effects of two picture types on prose learning. Additionally, the relationship between prior knowledge and picture-prose learning was examined. Based on the relevant theory and related research, the following predictions were made:

- H<sub>1</sub> There will not be a significant three-way interaction between time of testing (immediate versus delayed); prior knowledge (high versus low); and picture condition (conceptually integrated versus embedded versus prose only).
- H<sub>2</sub> There will not be a significant interaction between time of testing (immediate versus delayed) and prior knowledge (high versus low).
- H<sub>3</sub> There will be a significant interaction between time of testing (immediate versus delayed) and the picture conditions (conceptually integrated versus embedded versus prose only).
- H<sub>4</sub> There will be a significant interaction between prior knowledge (high versus low) and the picture conditions (conceptually integrated versus embedded pictures versus prose only).

The rationale for hypothesis 3 was based on the assumption that subjects in the picture groups would exhibit the least loss of memory on the immediate and delayed post-test in comparison with the control group. In addition, the conceptually integrated image would provide the learner with an intact structure for organizing the incoming information which according to Reynolds (1968) is consistent over time. Although the embedded picture groups lack this organizing feature, there would still be a delayed post-test effect due to the greater retrievability in memory of the pictorial information (Paivio, 1971).

In reference to hypothesis 4, individual differences in prior knowledge may have an effect on the role that illustrations play in learning (Dwyer, 1975). Illustrations may enhance or detract from learning. It is expected, however, that low prior knowledge students would particularly benefit from a pictorial adjunct.

## Chapter 3

### Method

A total of 88 subjects participated in the immediate posttest (Tables 1 and 2 give information on the age and sex of subjects). Data were collected from four intact classes; one management class (low prior knowledge)  $n=45$ , and three geography classes (high prior knowledge)  $n=43$ . On the delayed posttest this number was reduced to 68. The seemingly high attrition was partly due to losing one geography class ( $n=7$ ) due to illness on the part of the course instructor. Additionally, a number of students for whom immediate retention data had been collected were simply absent during the delayed posttest. Two subjects were excluded from the study since they did not attempt to participate in the free-recall task.

#### Prior Knowledge

The high prior knowledge sample was operationally defined as geography students who had successfully completed a six credit introductory geography course. This six credit course was a prerequisite for the second year geography classes which were used in the study. The low prior knowledge sample consisted of commerce students enrolled in a second year management course. Owing to the operational definition of prior knowledge, seven recreation students who were initially given permission to enroll in one of the geography classes were treated as low prior knowledge subjects (see Table 3).

#### Experimental Design

The experiment consisted of a two by three by two ( $2 \times 3 \times 2$ ) factorial design with repeated measures on the third factor

Table 1

Means and Standard Deviations of the  
Experimental Sample: Age

Experimental Group	Mean	Subject Age Standard Deviation
<u>High Prior Knowledge</u>		
Integrated (single illustration)	24.4	7.1
Embedded (inserted illustration)	22.6	3.0
Control	23.6	3.9
Total Sample	23.5	4.9
<u>Low Prior Knowledge</u>		
Integrated (single illustration)	23.3	5.4
Embedded (inserted illustration)	22.5	3.5
Control	22.1	2.8
Total Sample	22.6	3.9

Table 2

Absolute and Relative Frequencies for  
Sex of High and Low Prior Knowledge subjects

Experimental Group	Sex	Absolute Frequency	Relative Frequency
<u>High Prior Knowledge</u>			
Integrated (single illustration)	male	7	70.00
	female	3	30.00
Embedded	male	9	56.3
	female	7	43.8
Control	male	7	58.3
	female	5	41.7
Total	male	23	53.5
	female	15	34.9
Missing		5	11.6
<u>Low Prior Knowledge</u>			
Integrated (single illustration)	male	8	57.1
	female	6	42.9
Embedded	male	9	64.3
	female	5	35.7
Control	male	6	40.0
	female	9	60.0
Total	male	23	53.5
	female	20	46.5

Table 3

Absolute and Relative Frequencies on a self-reported "what is your major" question

Scale	Absolute Frequency	Relative Frequency (%)
<u>High Prior Knowledge</u>		
Geography	11	25.6
Urban Studies	12	27.9
Arts	3	7.0
no response	17	39.5
<u>Low Prior Knowledge</u>		
Commerce	28	65.1
Recreation	5	11.6
Arts	4	9.3
no response	6	14.0



(See figure 1). The three factors studied were prior knowledge (high versus low), two pictorial adjuncts (Conceptually integrated versus embedded versus control) and test interval (immediate versus delayed). Prior knowledge and the picture treatments were the between-group factors, while the test interval was the within-group factor. Two dependent measures were used in the current study. A multiple-choice test, which assessed knowledge and comprehension of the passage material, and a free recall test. In order to examine the long-term efficacy of pictures in memory, subjects were tested after reading the experimental passage (immediate free-recall and the multiple-choice test); and two weeks later (delayed free-recall and multiple-choice test). The significance level for the study was set at .05.

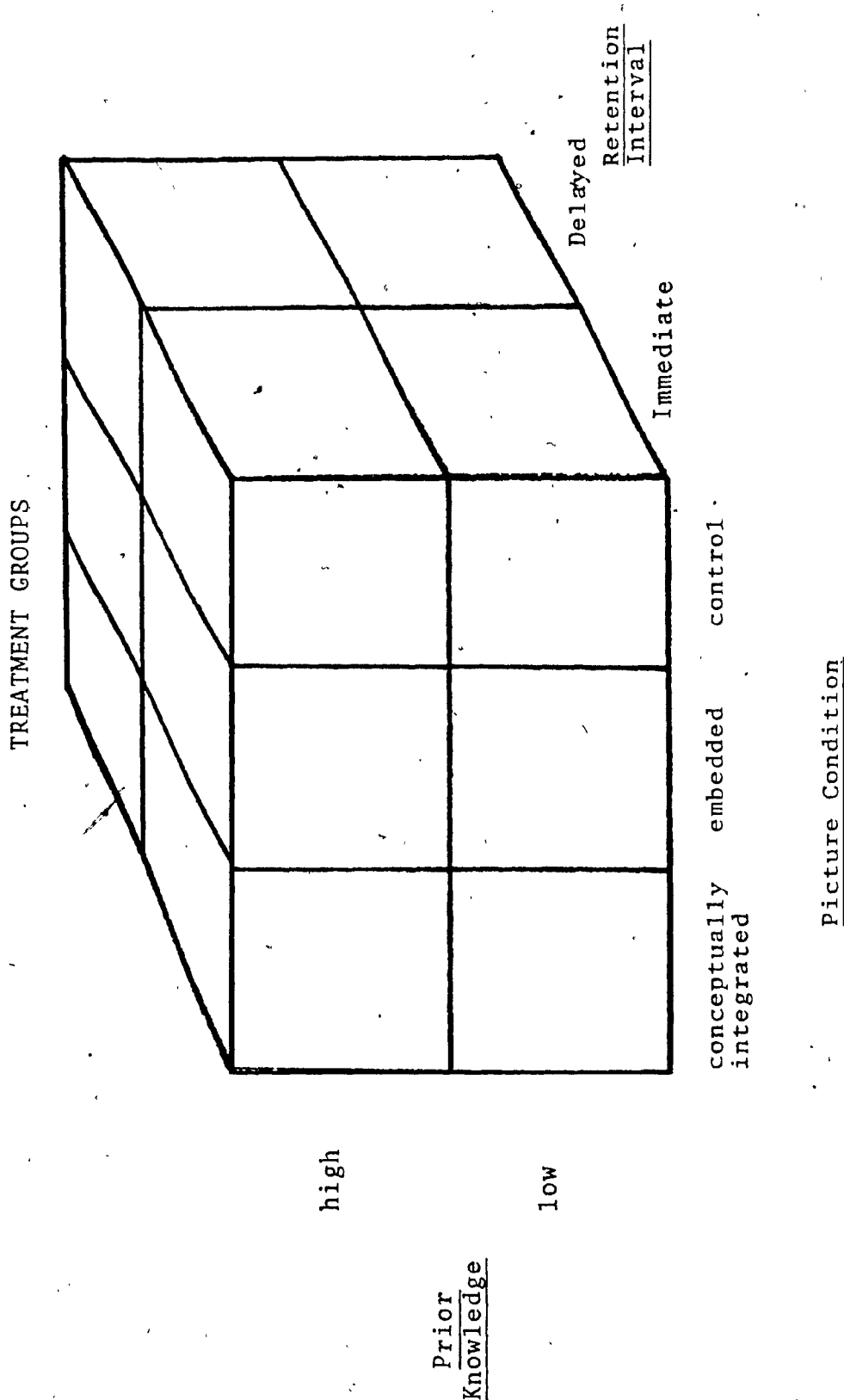


Figure 1. The Experimental Design

## Instrumentation

Multiple-Choice Test. The multiple-choice test was constructed by creating a pool of forty test questions. The test was designed to assess retention and comprehension of passage content as defined by Bloom's Taxonomy of Educational Objectives (Bloom, 1962). The forty questions consisted of twenty comprehension questions, ten knowledge questions and ten illustrated knowledge questions. Five of the illustrated test questions were drawn from the illustrations used in the picture treatments. Of these five questions, three questions were visually redundant with the verbal stem and provided no new information. The remaining five illustrated questions were drawn from the passage content and were not found in either of the two picture treatments.

The format of the multiple-choice test consisted of a verbal stem with three distractors and one correct answer. To ensure face validity, the questions were reviewed independently by a subject matter expert in the Geography Department. The content expert determined that the questions were clearly stated, and that only one of the possible responses was correct. Additionally, the correct response for each question was randomized within each question item so that guessing on the part of the students would result in only a slightly better than chance score.

The forty-item pool was pilot-tested with a sample (n=48) of similar subjects as those used in the main study. Due to the large number of multiple-choice items, the test was counter-balanced to offset any fatigue effect. Essentially, half of the students received questions 1 to 40, while the remaining half received the same questions in the reverse order. Ultimately, 25 multiple-choice items were selected based upon their internal reliability, i.e., Cronbach's  $\alpha$  and

item discrimination. The coefficient alpha for the pilot-test was .75.

In the main experiment, testing occurred during normal class hours. During the first testing session, subjects were not informed of a time limitation for completing the multiple-choice test. However, due to an unforeseen intervention by the class instructor, it was deemed necessary to impose a fifteen minute time period for completion of the multiple-choice test in the remaining classes. This, however, gave rise to some methodological problems in the study. Since subjects in the first class had not been informed of a specific time limitation for the test, roughly 38% of this class (n=11) were not able to answer all test questions. Whereas in the other classes used in the study, subjects were informed ahead of time that they had fifteen minutes and therefore were better able to gauge their time more efficiently. Since a mean of 4.8 test-items were not completed in the first class, the last five multiple-choice items were dropped from the immediate posttest for all subjects, thereby reducing the 25-item immediate posttest to 20 items. The two week delayed posttest consisted of the original twenty-five item multiple-choice test (Appendix E). The coefficient alpha for the twenty item immediate posttest was .69.

Free-Recall. Free-recall (number of idea units recalled) was used as the second dependent measure in both the immediate and delayed posttest conditions. Subjects were instructed to write down as much as they could remember from the prose passage. The scoring of the free-recall was based upon Schallert and Ulerick's (Note 10) prose analysis method.

In order to determine the content structure of discourse, relational mapping was used as a text analysis tool. This was achieved by examining the various concepts and their properties in a paragraph,

and then identifying their relationships with other subordinate concepts in order to disclose the overall macrostructure of a prose passage.

As specified by Schallert and Ulerick (Note 10), two sets of relational maps were developed independently by two reviewers who had previous experience with the technique. The final two sets of maps were almost identical, with ambiguities settled by mutual agreement. Idea units were then created by constructing a list of words and phrases which were explicitly graphed on the relational maps. The final free-recall scoring key consisted of 378 idea units (Appendix F).

Scoring the free-recall protocols. To ensure objectivity, all protocols were randomly ordered within the subject pool. Additionally, all identifying codes were removed from each subject's data sheet so that the experimenter would not be aware of the treatment conditions. The free-recall protocols were scored twice by the experimenter to ensure that there was consistency of grading throughout. The recall protocols were scored with the free-recall key in order to determine the number of idea units each subject remembered. This determination was made by comparing the idea units which were identical or synonymous with the primary recall key. One point was awarded for every idea unit that appeared in each student's protocol.

In order to assess the interrater reliability, a total of ten protocols were scored independently by a trained colleague. An unbiased estimation of reliability was obtained using Winer's (1962) analysis of variance approach. This was done independently for immediate and delayed free recall data. Results of the immediate data indicated that Rater 1 and Rater 2 were not significantly different,  $F(1,4) = .62$ ,  $p < .49$ . The reliability coefficient obtained was .92. For the delayed,

results were not significant for Rater 1 and Rater 2,  $F(1,4) = .36$ ,  $p < .59$ . The reliability coefficient obtained was  $r = .82$ .

Measure of Reading Ability. Prior to the initial experiment, subjects were administered the vocabulary portion of the Nelson Denny Reading Test. Due to time constraints, the cut-time modification of the NDRT vocabulary test for adult subjects was administered. Nelson & Denny (1973) reported that the intercorrelation between the vocabulary test and reading comprehension was fairly high ( $r = .619$ ) for a norming group of 525 grade 15 students. The total reading ability from the vocabulary and the comprehension scores was  $r = .95$ .

As per the instruction manual, subjects were informed that the vocabulary portion of the NDRT consisted of 100 items. They were instructed to work as quickly as possible and to score their responses on the provided score sheet. After completing the three practice exercises on the first page of the booklet, subjects were given an opportunity to ask questions. Subjects were then informed that they were allotted 7½ minutes to complete the test. Upon completion of the test, the booklets were collected. The NDRT scores were intended to be used as a covariate in the statistical analysis.

Interpolated Task. The interpolated task included in the experiment consisted of a series of math problems developed by Gellner (Note 5). The purpose of having subjects complete the task after reading the experimental passage was to insure that the dependent measures used were assessing long-term memory rather than short-term memory.

### Materials

Prose Passage. A 1,900 word passage consisting of 17 paragraphs was developed by the experimenter with the assistance of a subject matter expert. The material was drawn from a number of books on geography and meteorology. The passage dealt with a number of concepts and principles which affect the micro-climate of a city. For example, buildings, pavement and industry have an inadvertent affect on wind patterns, heat distribution and moisture levels. In the introduction, a general overview was provided which introduced some of the principles discussed later in the passage. Next, related concepts and principles were discussed in sequence. The article closed with a discussion on the benefits and hazards of weather related changes in the environment. Fry's Readability Formula (1968) of the passage yielded a readability equivalent to university level.

The particular topic 'The Urban Climate' was selected because it would be sufficiently unfamiliar to management students. It also dealt with a concept (the heat island effect) which was generally familiar to geography students who had completed a pre-requisite six credit course. In addition, the topic was part of the course content which one of the instructors intended to cover in class.

The pilot test, which was conducted during the summer session (1981), confirmed that the passage was unfamiliar to the management students. Unfortunately, due to a low class attendance in the geography class ( $n = 7$ ), it was impossible to gauge the differences in content familiarity between management and geography classes.

Illustrations. Six of the seventeen paragraphs were illustrated,

Design of the pictures was based on six concepts discussed in the passage.

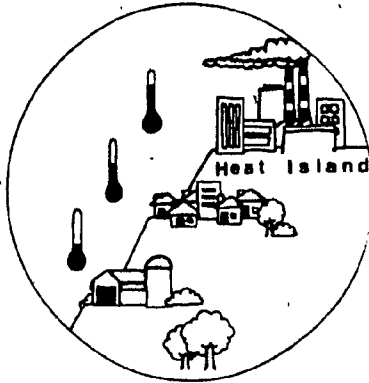
For example, the heat island; the soil heat flux in rural areas; water-proofing and artificial heat; and urban-rural circulation patterns. All six drawings were circular black and white stylized line drawings. In the conceptually integrated picture treatment, these six drawings were arranged in a linear order over a stylized drawing of a city and its surrounding countryside (See Appendix B). This arrangement of individual illustrations was based on recommendations by Winn & Holliday (Note 9) in which they found that learners tend to rely on reading convention while reading visual diagrams. The authors concluded that scanning direction was a powerful predictor of information processing.

The rationale concerning the inclusion of the city landscape below the individual drawings was two-fold. First, the function of the city drawing was to provide a stage-setting device such that it indicated the setting of the passage content (Levin, 1979). The circular drawings positioned over the city were representative of close-ups of the various processes occurring in the city and the countryside. The ordering of the individual pictures was based on the organization of the concepts in the passage. Secondly, it was hoped that this ordering of concepts over a realistic drawing of the city would result in the illustrated concepts being made more meaningfully related to the passage content, thereby making the illustration as a whole more integrated.

Adjacent to each circular drawing was a number. While reading, the learner was referred to the numbered illustration. In the embedded picture treatment, the learner was referred to the illustration which preceded the paragraph. Figure 2 shows a sample image from the embedded condition and a selection from the accompanying prose content.



average. Winter heat islands exhibit a weaker variation but can show more extreme urban-rural differences. The heat island



(REFER TO PICTURE) of a large city will generally show a plateau of elevated temperatures, which slopes gently away from the center, surrounded by a heat cliff in the suburban regions where the

(Figure 2)

All of the information contained in the visuals was designed to be redundant with respect to the printed material; they therefore contained little extraneous information.

The three conditions of the material were as follows: The prose only condition consisted of eight double-spaced typewritten pages (Appendix D). The passage for the conceptually integrated picture condition was identical except for the inclusion of verbal cues located at the beginning of each appropriate paragraph which referred the reader to a specific numbered visual contained in the adjacent illustration. The embedded picture condition consisted of eleven typewritten pages with use of verbal cues similar to the conceptually integrated passage. The reader, however, was referred to an embedded visual (Appendix C).

Pilot Test. Two intact groups of management (n = 34) and geography students (n = 7) were administered the experimental materials during regular class-time in the summer session at Concordia University. Envelopes containing the experimental material were randomly distributed, with all subjects receiving one of four experimental conditions. The fourth condition was a picture control in which subjects received only the conceptually integrated image and no passage.

The rationale behind the picture control condition was to assess the independence of the picture from the passage as a conveyor of information. The subjects were allowed fifteen minutes to study the materials. When the time had elapsed, the subjects were instructed to fill out a questionnaire on the difficulty of the passage and the usefulness of the illustrations. Finally, a forty-item multiple-choice test was completed by all subjects.

Results. Results from the questionnaire and the multiple-choice test indicated that the reading time for students who received illustrations with the passage was insufficient. Therefore, the reading time was extended from fifteen to twenty minutes for the main experiment. Picture related questions from the questionnaire revealed that 71% of the students found that the passage required illustrations. In addition, 63% felt that the illustrations represented the various concepts clearly. Finally, 76% felt that the illustrations helped them in reading the passage. Another 76% also indicated that the passage was unfamiliar, and 77% found it difficult. Additionally, the picture control groups in management and geography scored only slightly better than chance on the multiple-choice test.

Assemblage of Materials. The procedure of block randomization was used to randomize the three experimental treatments. Each package of materials was assigned a number and distributed to the subjects in numerical order. The packages and their contents are listed in order of presentation.

<u>Envelope</u>	<u>Time</u>	<u>Contents</u>
1.	20 min.	General instructions on outside of envelope. (Appendix A) Specific instructions with experimental treatment. (Appendix B, C, D)
2.	1 min.	Interpolated task (Appendix H)
3.	10 min.	Free-recall (Appendix F)
4.	15 min.	Multiple-choice test (Appendix E)

Procedure. The experiment was conducted during regular class hours.

In each class following a general orientation to the study, subjects received a Nelson & Denny Vocabulary test. After completing the vocabulary test, the booklets were collected. Each subject then received a package consisting of four numbered envelopes which were stapled together.

Each subject was assigned to one of the three conditions (conceptually intergrated, embedded and control) by random allocation of the material.

Subjects were instructed to work only on the contents of the assigned envelope and to refrain from opening other envelopes until directed to do so by the researcher in charge. Subjects were instructed to remove the contents of the first envelope. This consisted of the experimental passage with instructions stapled on the outside. After 20 minutes, subjects were told to replace the passage along with the Nelson Denny score sheet and take out the contents of the second envelope; the interpolated task. One minute later, subjects were directed to open envelope

number 3, the free-recall portion of the dependent measure. Ten minutes later, subjects were asked to stop writing and replace the test in the appropriate envelope. Subjects were then instructed to open the final envelope which consisted of the multiple-choice test and answer sheet. They were allowed fifteen minutes to complete this task. Upon completion of the posttest, all packages were collected and the experimenter promised to return with the results. Two weeks later, an unannounced delayed free-recall and multiple-choice test were administered in the same fashion as in the immediate testing.

## Chapter 4

### Results

#### Introduction

The purpose of this study was to determine the relative effectiveness of two forms of pictorial illustrations on learning from prose text. Secondly, the study examined whether the effectiveness of the illustrations would differ in students with high and low prior knowledge. Finally, the retentional effects of illustrations were examined over a two week period.

Covariate Predictor: The Nelson Denny Reading Test. Although Nelson Denny reading data were collected for use as a covariate (means and standard deviations are presented in Table 4) certain considerations warranted the removal of verbal ability as a predictor of subject performance. As noted earlier in Chapter 3, the cell sizes of the treatment groups were relatively low due to attrition, as well as a class being cancelled. In addition, Nelson Denny Vocabulary data were missing from three of the subjects, which would have further reduced the cell size. Furthermore, one subject had a total score of one in the NDRT. The low score reflected not so much a lack of vocabulary skill, as disinterest for that particular task, since only five items in the test were attempted. Hence, in order to eliminate the subject with the lowest score, it would have been necessary to remove the subject with the highest score. A total of five subjects would have been excluded from the analyses.

In order to avoid reducing the cell sizes even further, and to obtain empirical confirmation of the equivalence of the groups on the

covariate, a two-way analysis of variance (ANOVA) was conducted using the NDRT as the dependent measure. In testing for the assumption of randomization, Huitema (1980) suggests using a liberal level, therefore, the level of significance was set at  $\alpha = .10$ .

Table 4.

Means and Standard Deviations  
of the Total Sample on the Nelson Denny Reading Test

Experimental Group	Nelson Denny Reading Test Mean	Standard Deviation
<u>High Prior Knowledge</u>		
Integrated (single illustration)	32.27	16.70
Embedded (inserted illustration)	38.94	21.43
Control	35.08	12.48
<u>Low Prior Knowledge</u>		
Integrated (single illustration)	29.07	16.90
Embedded (inserted illustration)	30.64	12.43
Control	33.20	13.98
Total Sample	33.35	15.97

Analysis of the data revealed no significant main effect for prior knowledge,  $F(1,77) = 1.68$ ,  $p > .20$ , and no significant main effect for the picture conditions  $F(2,77) = .50$ ,  $p > .60$ . There were no significant interactions. Based on the above considerations, the groups were considered to be equivalent in reading ability and therefore, the NDRT was not used as a covariate in the statistical analysis.

#### Multiple Choice Posttests

Due to the quantitative differences in question items between the immediate (20-items) and the delayed (25-items) posttests, separate analyses were performed on the two multiple-choice tests. See Table 5 for means and standard deviations.

Immediate Multiple Choice Posttest. The 20 item immediate multiple-choice posttest was analyzed by a two-way analysis of variance (ANOVA). Results showed that there was a significant main effect for prior knowledge,  $F(1,85) = 4.61$ ,  $p < .04$  (see Table 6). The main effect for picture treatment and the interaction of prior knowledge and picture treatment were not significant,  $F(2,85) = .14$ ,  $p < .87$  and  $F(2,85) = .62$ ,  $p < .54$ , respectively.

Delayed Multiple Choice Posttest. The 25 item delayed posttest was also analyzed by a two-way analysis of variance (see Table 7). The main effects of prior knowledge  $F(2,67) = 2.82$ ,  $p < .10$ ; and picture treatment were not significant. Additionally, there was no interaction between prior knowledge and picture treatment.

Knowledge and Comprehension Questions. To more closely examine the

treatment effects on knowledge and comprehension, a two-way analysis of variance was performed separately on the immediate and delayed posttest scores.

A test of the immediate knowledge scores yielded no significant differences between levels of prior knowledge,  $F(1,84) = 1.79$ ,  $p < .19$ ; picture treatment,  $F(2,84) = 18$ ,  $p < .84$ ; and no interaction  $F(2,84) = .33$ ,  $p < .73$ .

Table 5.

Means and Standard Deviations for Experimental  
Groups on Immediate and Delayed Multiple Choice Posttests

Experimental Group	Immediate Posttest (20 items)			Delayed Posttest (25 items)		
	$\bar{X}$	SD	n	$\bar{X}$	SD	n
<u>High Prior Knowledge</u>						
Integrated (single illustration)	10.69	8.33	13	12.33	5.09	9
Embedded (inserted illustration)	11.12	3.50	16	13.91	3.80	11
Control	11.21	3.62	14	14.00	3.68	10
<u>Low Prior Knowledge</u>						
Integrated	10.29	3.07	14	11.14	2.34	14
Embedded	9.33	2.99	15	12.36	3.26	11
Control	8.86	3.39	14	12.23	3.81	13
Total Sample	10.25	3.34	86	12.57	3.66	58



Table 6

Analysis of Variance Summary Table for  
Immediate 20-item Multiple-Choice Posttest

Source	SS	degrees of Freedom	MS	F Ratio	Sig Level
Prior Knowledge (P)	51.04	1	51.04	4.61	$p < .04$
Illustrations (I)	3.12	2	1.56	.14	$p < .87$
P X I	13.82	2	6.91	.62	$p < .54$
Within (error)	884.78	80	11.06		
Total	952.37	85	11.20		

Table 7

Analysis of Variance Summary Table for  
Delayed 25-item Multiple-Choice Posttest

Source	SS	degrees of Freedom	MS	F Ratio	Sig Level
Prior Knowledge (P)	37.65	1	37.65	2.82	$p < .10$
Illustrations (I)	27.39	2	13.69	1.03	$p < .37$
P X I	.95	2	.47	.04	$p < .97$
Within (error)	827.48	62	13.35		
Total	898.63	67	13.41		

Analysis of the immediate comprehension scores yielded a main effect for prior knowledge such that  $F(1,85) = 4.75$ ,  $p < .04$ . There was no significant main effect for picture type.

A similar situation occurred with the delayed knowledge and comprehension scores. However, for knowledge related questions a main effect was found for prior knowledge  $F(1,67) = 4.01$ ,  $p < .05$ . No significant differences were found for picture treatment  $F(2,67) = .63$ ,  $p < .54$ . There was no interaction found between prior knowledge and picture treatment. In examining the delayed comprehension scores, no differences were observed between prior knowledge  $F(1,67) = .05$ ,  $p < .82$ ; and picture treatment  $F(2,67) = .66$ ,  $p < .53$  and no interaction between prior knowledge and picture treatment.

Free-Recall. The free-recall protocols were scored according to the criteria described in chapter 3. Table 8 presents the means and standard deviations of the treatment groups. Program BMDP 2V analysis of variance with repeated measures was used to analyze the data (refer to Table 9). The analysis yielded a significant main effect for time;  $F(1,62) = 67.5$ ,  $p < .001$ . There was a significant main effect for prior knowledge  $F(1,62) = 5.52$ ,  $p < .03$ . Similarly, the analysis revealed an overall effect due to picture treatment  $F(2,62) = 2.98$ ,  $p = .05$  (refer to Figure 3). The interaction between time of testing and the picture condition was not significant  $F(2,62) = 1.94$ ,  $p < .16$ ; nor were any other interactions.

Post Hoc Analysis. Post hoc Duncan's multiple-range test yielded a significant difference at the .05 level between the embedded picture condition and the other two conditions such that embedded > conceptually

Table 8

Means and Standard Deviations for Experimental Groups on Immediate and Delayed Free Recall Dependent Measure

Experimental Group	Immediate Free Recall Protocol			Delayed Free Recall Protocol		
	X	SD	n	X	SD	n
<u>High Prior Knowledge</u>						
Conceptually Integrated	19.7	8.1	9	15.8	6.8	9
Embedded	29.0	10.0	11	24.3	8.6	11
Control	24.5	6.7	10	19.3	8.2	10
<u>Low Prior Knowledge</u>						
Conceptually Integrated	21.0	7.4	14	14.8	8.4	14
Embedded	21.5	9.6	10	17.4	7.1	10
Control	21.1	7.9	14	11.3	5.1	14

Table 9

Analysis of Variance with Repeated Measures  
for Free-Recall Posttests.

Source	SS	df	MS	F ratio	p
<u>Between Groups</u>					
Prior Knowledge (P)	592.1	1	592.1	5.52	p<.03
Illustrations (I)	639	2	319.5	2.98	p<.06
P X I	328.4	2	164.2	1.53	p<.23
Error	6650.3	62	107.3		
<u>Within Groups</u>					
Time (T)	1060.	1	1060.	67.5	p<.001
T X P	37.5	1	37.5	2.36	p<.13
T X I	60.9	2	30.5	1.94	p<.16
T X P X I	38.6	2	19.2	1.23	p<.30
Error	973.8	62	15.7		

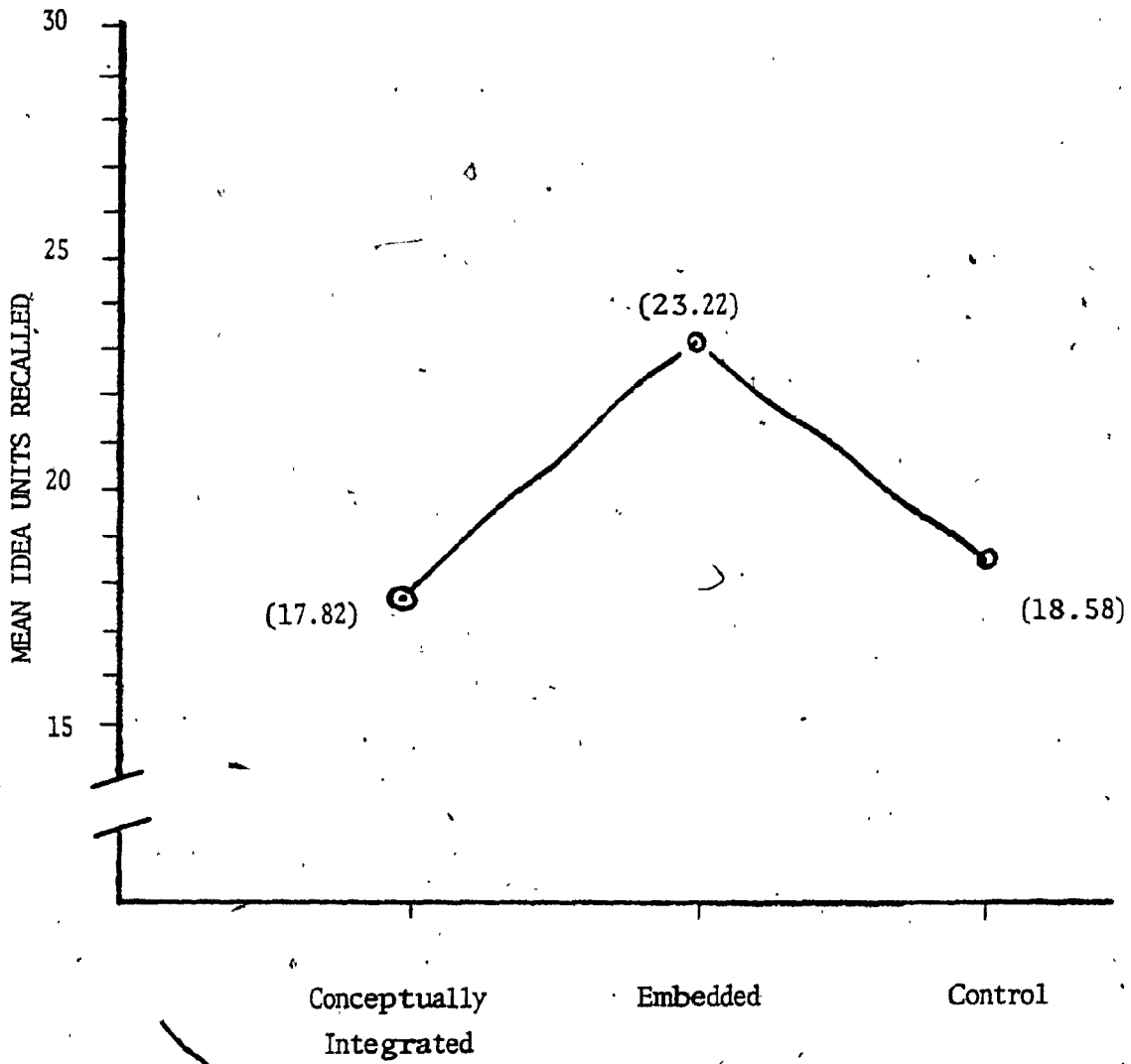


Figure 3.. Comparison of free-recall means across treatment conditions.

integrated = control.

Conclusions.

Hypothesis 1 was supported. There was no three-way interaction between time of testing, picture condition, and prior knowledge.

Hypothesis 2 was also supported. There was no interaction between time of testing and prior knowledge.

Hypothesis 3 was not supported. There were no interactions between time of testing and the picture conditions. However, there was a main effect over time and a main effect for picture treatment which favored the embedded picture condition.

Hypothesis 4 was not supported. There was no interaction between prior knowledge and the picture conditions. High and low prior knowledge subjects performed equally well with the embedded picture condition.

## Chapter 5

### Discussion

This study assessed the effectiveness of two alternate forms of picture type on prose learning. In addition, the influence of prior knowledge on learning from illustrated and non-illustrated text was also addressed.

#### Pictorial Effects on Learning from Prose.

In comparing student performance on both the multiple-choice dependent measures, no differences were found between the various treatment groups. However, examination of the free-recall dependent measure revealed a significant main effect for picture treatment, favoring the embedded picture condition.

The discrepancy exhibited between the two dependent measures may be partly explained within an organizational context. Specifically, there is some research evidence which suggests that a cued recall test, or for that matter a multiple-choice test, may not be sensitive enough to gauge the retrieval of passage-related information from memory (Shimmerlik, 1978). According to Shimmerlik (1978), a cued recall dependent measure may conceal certain organizational effects provided by adjuncts. However, in a free-recall situation, the learner is able to make more efficient use of an intact retrieval schema for calling up prose content. In addition, Duchastel (Note 1) has argued that illustrations better facilitate the recall of broad schemas of information as opposed to specific segments of knowledge typically measured by a multiple-choice test.



In the current study, it was hypothesized that the conceptually integrated image would provide greater organizational benefits than the embedded picture treatment. This was based on several theoretical assumptions. First, the success of integrated map-like images has been documented by Reynolds (1966; 1968) and corroborated by Spangenberg (1971). Secondly, providing the learner with advance notice on the conceptual organization of the content (Shimmerlik, 1978) and its sequence in the passage (Staley & Wolf, Note 3) has been shown to provide greater learning gains. However, the results of the current study did not support the beneficial effects of the conceptually integrated image. In fact, the no-picture group performed slightly better on the free-recall in comparison to the conceptually integrated picture group. This suggests that there are instructional situations which do not benefit from the use of pictures as adjuncts to prose.

This notion has received support from a study by Holliday (1976). He hypothesized that verbal chain information would be more effectively learned through the use of a structurally coherent display similar to Spangenberg's (1971) versus the same display plus text, or text only. Two flow diagrams were used, a picture word diagram which illustrated a relatively complex biogeochemical cycle with words and pictures plus a block-word diagram illustrating the same verbal information with black and white geometric symbols. The results showed that the two diagrams were significantly more effective than the diagram plus text groups. In addition, there were no differences between the diagram-plus-text and the text only, which is consistent with the findings from the current study. Holliday raises an important point which may underlie the non-significance shown by the conceptually integrated image. He suggests that the students may have ignored the adjacent illustration. This then

might account for the relatively similar means found between the diagram-plus-text group and the control group. As Olson (1977) points out, there is a literate bias in schooling which places a great importance on verbal learning. If students believe that they can obtain the same information from the text, then they will do so to the detriment of the visual information. Similar conclusions were also reached in a study by Dean and Kulhavy (1981). They found that a map-like organizational device provided the learner with a more stable organizational schema only when the learner was forced to encode it. In this particular case, the students actually drew the map. The subjects who received an identical map-like illustration performed no better than the control group. The authors concluded that merely providing an adjacent organizer is no guarantee that it will be processed by the learner.

According to Levie and Lentz (Note 11), pictorial adjuncts such as diagrams and maps may be less effective as adjuncts than conventional images or representational images. However, this is primarily due to the learners' lack of knowledge in using such adjuncts. In commenting on this, Salomon (1981) also points out that:

'For a representation to issue the information easily it must fit into the context of developed schemata with minimal re-coding. If such representations have been frequently encountered in the past, thereby cultivating appropriate anticipatory schemata, and if a new representation looks in symbolic structure very much like the previous ones, then it is considered "stereotypic", as it fits into the pre-existing mental context' (p. 201-202).

In conclusion, Levie and Lentz suggest that prompts, such as those used by Holliday (1976) and Dean & Kulhavy (1981), or training, will provide a more accurate estimation of whether or not these adjuncts contribute to greater learning gains.

### Differences in Prior Knowledge

Although not totally consistent, results from the study indicated that there were definite differences in the prior knowledge of students. In general, high prior knowledge students recalled a greater number of idea units and achieved higher learning gains on the immediate multiple-choice test. It is difficult to provide a definitive answer as to why the high prior knowledge students showed greater gains on the comprehension questions on the immediate posttest. Yet no differences were evident on the delayed posttest except for knowledge questions. One plausible explanation may lie in the repeated use of the same multiple-choice test for the immediate and the two-week delayed posttest conditions. In general, unlike the low prior knowledge subjects, high prior knowledge subjects were tested late in the afternoon or evening. The lack of prior knowledge differences in the delayed posttest (except for knowledge questions) may have been due to a decline in student motivation combined with test familiarity. It is possible, therefore, that the high prior knowledge students may have felt that they had done enough, particularly after completing the more demanding free-recall posttest.

### Prior Knowledge and Learning from Illustrated Text

Initially, it was hypothesized that there would be a significant interaction between prior knowledge and the picture treatments. It was argued that high prior knowledge learners possessed richer, more complex stores of schemata (Anderson, 1980) than low prior knowledge learners. High prior knowledge learners, therefore, might not benefit from illustrated text since the prose content would be sufficiently familiar to allow learners to apply their own encoding strategies (Dwyer, 1978).

On the other hand, various studies have shown that pictorial contexts (Bransford and Johnson, 1972) assist learners in 'calling up' appropriate schemata (Anderson, 1977) in order to comprehend abstract or ambiguous passages. Of particular importance in the Bransford & Johnson study (1972) was the assumption that prior knowledge is necessary in order for comprehension, and therefore learning and memory to take place. Prior knowledge, however, does not guarantee greater learning gains. What is important is that knowledge must be activated if comprehension is to occur (Bransford & McCarrell, 1974). One way of activating prior knowledge is to provide an appropriate pictorial adjunct which the learner can make use of during processing to ensure that the information is transferred into long-term memory (Reder, 1980).

Additionally, a pictorial adjunct may also provide a supplanting function in learners who lacked the necessary cognitive skills (Salomon, 1972). Given the repertoire of information processing abilities of learners, Salomon (1979) has maintained that providing learners with identical visual adjuncts may or may not lead to an increment in learning. A pictorial adjunct may assume a supplanting function if it is compatible with the learners' own processing strategies. A complex visual display, such as the conceptually integrated image, would therefore provide greater facilitative effects for the high prior knowledge learners than the low prior knowledge learners.

Results from the study showed a main effect for prior knowledge and for picture treatment, but there was no interaction between prior knowledge and picture treatment. That is to say, the embedded picture treatment was effective for both levels of prior knowledge. A number of explanations may account for these results. Mentioned earlier and reiterated here is the fact that learners may have simply ignored the

conceptually integrated image. It has been convincingly stated that even the best designed visual will not improve prose learning if learners do not make use of it (Schmid, Note 12).

A second interpretation may lie in the variability among the levels of prior knowledge within the high prior knowledge group. As evidenced by the questionnaire data (refer to Table 10), a substantial number of geography students indicated that they were not highly familiar with the passage content. If the students found the prose content too abstract and difficult to comprehend, then the facilitating effects of an interpretive pictorial adjunct on prose learning would be diminished (Levin & Pressley, 1978). Additionally, if the students found the passage overly complex, then the inclusion of a complex visual display would further confound the situation. Indeed, Sclichcinski (1979) has proposed that some visuals require a certain amount of background knowledge in order to be understood. As Salomon points out: '...a picture is worth a thousand words only when they have been uttered before the picture is seen' (p. 392, 1974). Supposedly, this information was provided in the prose content which preceded the embedded pictures.

In conclusion, the results from the study favor the addition of text-embedded pictorial adjuncts and support the findings of Peck (1974) and Haring & Fry (1975). Similar to the partial pictures used by Ruch and Levin (1977), the embedded pictures may have provided both high and low prior knowledge learners with a schema-evoking context (Bransford & Johnson, 1973) for organizing the incoming information. According to Ruch & Levin (1977), partial pictures which are provided prior to the text stimulate deeper levels of processing in the learner. The significant differences in prior knowledge would account for high prior knowledge learners having instantiated a greater number of variable

Table 10

Absolute and Relative Frequencies on a  
self-reported "Familiarity with Passage" question

Scale	Absolute Frequency	Relative Frequency (%)
<u>High Prior Knowledge</u>		
not familiar at all	1	8
	2	10
	3	7
	4	9
very familiar	5	3
no response	6	14.0
<u>Low Prior Knowledge</u>		
not familiar at all	1	20
	2	6
	3	5
	4	9
very familiar	5	1
no response	2	4.7

slots in memory during the initial processing of the picture contexts. This provides confirmatory evidence that how much a person remembers from a prose passage is based largely on the learners' existing knowledge (Anderson et. al, 1977):

#### The Retentional Benefits of Illustrations

It was hypothesized that there would be a significant interaction between time of testing and the picture conditions. The results from the current study were not fully supportive of the long term benefits of illustrations owing to a marginal interaction between time and picture treatment ( $p < .16$ ).

While many researchers have advocated the necessity of testing the effectiveness of adjuncts over time (Barnes & Clawson, 1975; Shimmerlik, 1978; Haring & Fry, 1980; Peeck, 1975; Duchastel, Note 1; Gellner, Note 5) it is often overlooked in many picture-prose studies. Additionally, numerous picture studies (Bernard et. al, 1981; Dean & Kulhavy, 1981; Duchastel, Note 1) also fail to incorporate an interpolated task, or report its inclusion as part of the research design. Since the primary purpose of an interpolated task is to diminish a recency effect and better assess long-term memory, the inclusion of an interpolated task provides a more accurate estimate of the retentional benefits of illustrations even in the immediate posttest.

Overall, the results from the immediate and delayed free-recall posttests suggest that the embedded picture condition provided better long-term retention of the passage content. This supports Paivio's Dual Coding Theory which proposes that the dual processing of images and words results in a stronger memory trace of the information. Given the relatively abstract nature of the prose material used in the current study,

it may have been difficult for students to generate their own mental images. The information would therefore have been encoded verbally. The embedded pictures, however, were encoded both visually and verbally, thereby ensuring that they would be retained in memory longer.

An important question still remains. Why is it that the conceptually integrated image did not equally facilitate learning, given the fact that it essentially conveyed the same pictorial information? Although a number of explanations were touched upon earlier, perhaps the answer lies in the retrieval of the illustrations from memory.

It has been proposed that visual information is encoded spatially in memory (Paivio, 1971; Mandler and Parker, 1976) and that individuals possess an impressive memory capacity for pictures (Standing et al, 1972). During recall, it is the process of reconstructing a spatial image which assists the learner in remembering the various elements and the relationships between them (Winn, 1980). Therefore, the more realistic the spatial patterns are in a picture, the greater the recall of the verbal and pictorial information contained in the picture. During recall, the conceptually integrated image as a whole lacked the spatial realism that the individual pictures possessed. Therefore, the embedded pictures were more easily retrieved from memory, which may account for their greater effect on learning.

In conclusion, it appears from previous research findings that pictures do facilitate learning. However, some researchers believe that it is important to exploit the unique characteristics of pictures, such as their spatial properties, if pictorial benefits are to be found (Schallert, 1980).



### Conclusions and Implications

The findings from the current study indicate a superiority of embedded pictures in comparison to a single pictorial adjunct. Exactly why this is the case is not clear. However it had been suggested that students have a tendency to ignore an adjacent pictorial aid in favor of the prose material. The embedded pictures might have had a stronger attentional effect and therefore provided a greater mediational activity between the learner and the prose. Verbal learning research has shown that the placement of an adjunct has an important influence on how people learn. Future picture research should examine how placement may be manipulated in order to optimize learning.

Although the conceptually integrated image showed no beneficial effects, the use of multi-images in slidetape productions has proven to be an effective teaching tool (Jonassen, 1979). Duchastel has pointed out that:

'Much more needs to be done however to establish which arrangements of illustrations are harmful and which are helpful and whether certain trade-offs of effects are warranted...' (p. 285, 1981).

In addition, it has been proposed that individual differences in cognitive style, such as field-dependence and independence, may influence the effectiveness of complex visuals such as the conceptually integrated image (Salomon, 1974). According to Salomon, a field-dependent learner might find a complex visual difficult to interpret and therefore would better benefit from an equivalent verbal adjunct.

Although a number of studies have found facilitative effects of pictures on comprehension, no such results were found in the current study. However, the broad grouping of free-recall into reading comprehension has been noted in several picture studies (i.e., Bransford & Johnson, 1972; Haring and Fry, 1979). This diversity in the measurement of

comprehension gains does little in clarifying how illustrations affect learning. However, the use of free-recall in examining the structure of prose in memory is a valuable tool. If this study had evaluated learning solely in terms of the multiple-choice test, no results would have been found. Although the experimenter only examined learning outcomes in terms of quantity of idea units, the Schallert and Ulerick (1980) discourse analysis method provides a more detailed analysis in determining macro and micro idea units. Given that the discourse analysis method is far more sensitive in evaluating memory of connected discourse, it should be considered for use in conjunction with a multiple-choice test in picture research.

The relative importance of prior knowledge in determining how effective verbal adjuncts are, has been voiced by Ausubel and Fitzgerald, (1962). Many researchers such as Anderson et. al. 1977; and Sulin and Dooling, 1974; have provided evidence that prior knowledge affects memory for prose. It is becoming increasingly obvious, therefore, that prior knowledge should be removed from its peripheral status and be investigated more closely in the area of picture research. In relation to the current study, one method of determining prior knowledge would be to pretest students on their knowledge of various concepts rather than relying on subjective verification.

Dual coding theory also offers an explanation for the effectiveness of the retentional role of illustrations over time. Earlier research has shown that when pictures and words are compared in a free recall paradigm, pictures are superior (Snowman, 1973). Similarly, when applied to verbal discourse, pictures appear to remain relatively stable in memory and are able to facilitate recall of the prose text.

Taken together, data obtained in the current study demonstrate

that embedded images contributed to greater learning gains. Further research might examine a combination of the two pictorial treatments. In other words, present learners with an overview along with the embedded components of the overview. According to Shimmerlik (1978), providing learners with two different contexts results in greater quantitative and qualitative differences in recall than a single organizational adjunct alone.

In conclusion, the examination of pictures used in conjunction with prose text appears to be a multifaceted consideration for researchers. If, however, a more systematic and, most importantly, a theoretically oriented approach is taken, the end results could substantially contribute to the improved design of reading materials.

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APPENDICES

APPENDIX A

General Instructions

DIRECTIONS

This study is being conducted for the purpose of improving upon the quality of instructional textbooks. Therefore, your participation is needed in order that guidelines are developed which can be used by writers of instructional materials.

This package consists of four (4) separate envelopes of material. You will be guided through these envelopes by the researchers in timed steps.

You are asked to follow the researchers' directions closely. They will advise you when to start each task and when the time allotted for study of the material has expired.

When the task has been completed, insert the materials back into the proper envelope and wait quietly for others to finish. Please do not look through subsequent envelopes until the researcher in charge of the study gives the go-ahead.

Please note that other students in the room will be working on slightly different materials, so we ask that you ignore them and attend to your task only.

DO YOU HAVE ANY QUESTIONS REGARDING THESE INSTRUCTIONS?

Thank-you for your  
assistance and cooperation!

APPENDIX B

Conceptually Integrated Condition

DIRECTIONS

You will have twenty minutes (20) in which to study the following passage entitled 'The Urban Climate'. The passage is eight (8) typewritten pages long.

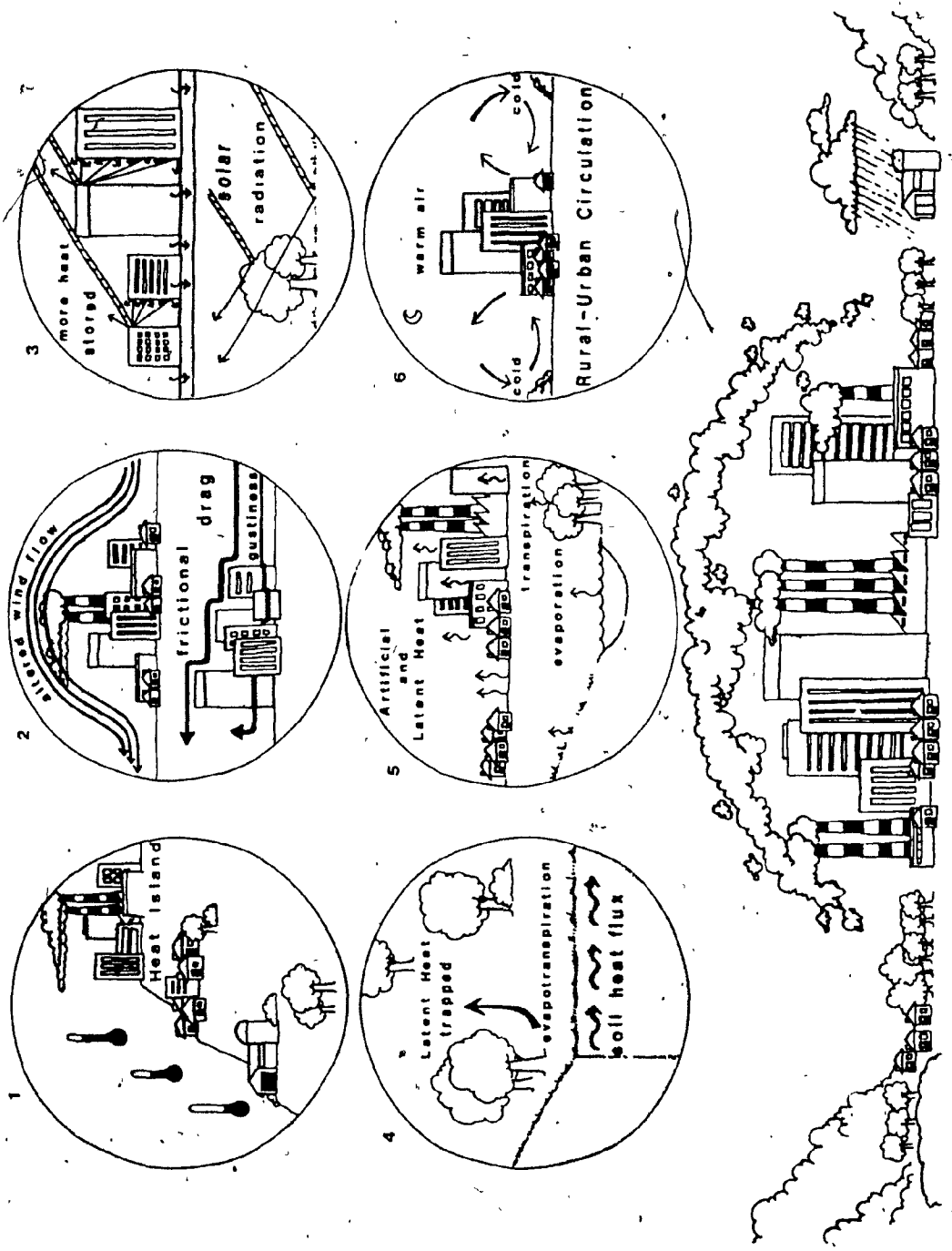
Pay particular attention to the illustration included with the passage, and refer to it while you are reading. It has been designed to assist you in remembering and comprehending the print material.

Please attend to the passage very carefully, because you will be asked to write down as much as you can remember from the passage once you have finished. The final task is a twenty-five (25) item multiple-choice test which will assess how well you understood and remembered the information contained in the illustration and in the passage.

If you have any questions, please raise your hand and you will be assisted.

PLEASE DO NOT TURN THE PAGE  
UNTIL INSTRUCTED TO DO SO.





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## The Urban Climate

If the object of building construction is to create an artificial climatic environment in which the optimum physiologic needs of man are met, then it has been highly successful. Given present day technology and sufficient funds, it is possible to produce an interior environment in which light, heat and humidity conditions can be regulated to meet any contingency. The construction of such an internal environment however, cannot be achieved without modifications of the pre-existing external conditions and as a by-product of meeting human living requirements, a new set of climatic conditions are created.

Buildings that are designed for control of their internal climates also affect the microclimates in their vicinities by influencing air movement, heat exchange, and moisture flux. Anyone who has contrasted the microenvironment over a hot pavement with that over a green lawn has a practical appreciation of man's influence. Roads are commonly drier than adjacent land, have a lower albedo and are more likely to be travelled by sources of atmospheric pollutants. The construction of an embankment across a small valley can disrupt air flow and create a distribution of temperature that is reflected in the composition of plant communities. The effects of factories, parks and swamp drainage are additional random examples that illustrate the ways in which man and his works modify climate on a small scale. Any

change in albedo, water capacity and retention, evaporation, transpiration, or surface roughness may produce a change in climate, but the results are complex, difficult to measure and not easily predicted.

The city, like its surrounding countryside, is immersed in the lower layers of the earth's atmosphere, and it is the properties and behavior of this fluid and the way the city shares its energy with the atmosphere that provide the dominant link between man's urban activities and the climate he lives in.

The individuality of any climate relates to the flux of energy that arrives at a surface and the manner of its subsequent distribution. The amount of energy received at a surface depends upon earth-sun relationships together with the way in which the solar beam is modified as it passes through the atmosphere or is reflected from the surface.

On an annual average, downtown urban temperatures at or near the surface are characteristically higher than in the surrounding countryside. This annually averaged difference is typically of the order of  $1^{\circ}$  F. but depends on the size of the city, the latitude, and the amount of energy conversion. The strongest contribution to this annual average comes from "fair weather" situations, in which the city and the countryside both warmup during the day, but the countryside cools off more rapidly. By late afternoon or early evening the city has become definitely warmer by comparison, and the magnitude of the temperature

difference continues to grow for some time after sunset. This passive differential cooling mechanism can be aided considerably by artificial energy released within the urban complex. Heat generated by domestic space heating, transportation and industrial activities dominates the winter energy budgets of many northern cities and leads to the formation of strong 'heat islands' on clear winter nights.

In summer and early autumn, heat islands are sometimes barely detectable during the day but often exhibit temperature excesses of  $10^{\circ}$  F. or more, which strongly affect the annual average. Winter heat islands exhibit a weaker variation but can show more extreme urban-rural differences. The heat island of a

(REFER TO PICTURE 1)

large city will generally show a plateau of elevated temperatures, which slopes gently away from the center, surrounded by a heat cliff in the suburban regions where the temperatures fall off rapidly to match those of the surrounding countryside. The plateau will exhibit local maxima corresponding to energy-intensive industry, and the cliff will be eroded by local topographic effects due to local valley drainage winds and lake or sea breezes. The amount of warming which occurs with a heat island correlates with a cities growth rate. In consequence, as the heat island expands and intensifies, stronger and stronger regional winds are needed to overcome it and dissipate the heat beyond the city. However, it is unwise to consider the heat island of surface temperature

excess without considering the way in which the city shares its energy with the atmosphere boundary layer in which it is immersed.

Net radiation is a term used to describe a heat gain by day and a heat loss by night in both the city and the surrounding countryside. Solar radiation over the city is markedly weakened by having to penetrate the pollution haze ( and hence tends to be strongest at weekends, when there is less pollution ). About 80% of the solid contaminants in the urban atmosphere are in the form of particles that are small enough to remain suspended for several days. Although these particles collectively tend to reflect solar radiation, thereby reducing the amount of radiation reaching the surface, they also tend to retard the out-flow of heat.

The varied geometry of a city skyline introduces a high

(REFER TO PICTURE 2)

degree of surface roughness into the landscape which exceeds that of most rural areas. The chief impact of this (aerodynamic) roughness is on the air flowing over the urban surface, so that mechanical turbulence is set up. The total effect of this frictional drag is to reduce windspeeds within the built-up area, although localized turbulence and eddying leads to marked increases. Investigations suggest that the roughness increases with the width of the building and the square of its height, but is inversely proportional to the size of the lot occupied by the

building. Radiation from below also causes the heat island to act as a mound barrier to surface air flow. This also proportionately lengthens the time required for the wind to flush air pollutants from the city.

Different surfaces also have different reflective

(REFER TO PICTURE 3)

characteristics and the city comprises a multitude of surface varieties which function like a maze of reflectors, absorbing some of the energy they receive and directing much of the rest to other absorbing surfaces. It is also note-worthy that the vertical extent of city buildings will further cause the overall amount of reflection possible to vary markedly even within the city and to continue even while the sun is low in the sky.

Modification of a surface can also modify the net radiation by altering the albedo. The city has a lower albedo because of the darkly coloured streets, so that it absorbs solar radiation better. The greater thermal conductivity of the urban fabric results in a considerably enhanced storage of heat. The soil heat flux is a surface loss by day and a gain by night in both environments. In the city however, this flux is partly replaced by fluxes into and out of the concrete and tarmac of roads and buildings, therefore they have a higher heat capacity than the soil of rural areas.

(REFER TO PICTURE 4)

In rural areas, the ground receives heat during the day

and cools off during the night, but vegetation acts as an insulating blanket ( in large part by trapping still air through which heat moves slowly ). The soil heat flux contained in the ground is therefore reduced. During the day, the grass blanket keeps heat from flowing into the soil. This would leave more at the surface to heat the air except that evapotranspiration from the vegetation helps to lower temperatures. At night, the temperature at the top of the grass drops owing to re-radiation back to the atmosphere, but the insulating blanket prevents considerable heat flow from the soil below.

The rapid runoff of rainfall caused by the imperviousness

(REFER TO PICTURE 5)

of the surfaces of roads and roofs as well as by the drainage system is another major effect of cities. This waterproofing involves a hydrologic change with climatic consequences. Except in limited green areas and parks, the pathways taken by moisture is quite limited in the city. Transpiration, infiltration ( to both ground and soil water ) and evaporation are radically reduced. The amount of surface standing water is reduced to a minimum with the result that energy available for latent heat is increased significantly. This is significant because the evaporation process removes heat from the air ( approximately 600 calories for every gram of water evaporated ) and hence has a cooling effect at the earth's surface.

The heat island is not merely a surface effect. A few hundred meters of the atmospheric boundary layer are also heated and special wind effects are sometimes observed. One such immediate consequence of the heat island is increased convection over cities, especially in the daytime. This has been beautifully demonstrated by the lift given to constant-volume balloons launched across cities. The up-draft leads, together with the large amount of water vapor released by combustion processes and steam power, to increased cloudiness over cities. It is also a potent factor in the increased rainfall reported from cities.

(REFER TO PICTURE 6)

Even at night the heating from below will counteract the radiative cooling and produce a positive temperature lapse rate (temperature which increases with increasing altitude), while at the same time inversions form over the undisturbed countryside. This together with the surface temperature gradient, creates a pressure field which will set a concentric country breeze in motion. This localized rural-urban circulation pattern does not accelerate because the buoyant lift of rising warm air is balanced by friction due to the aerodynamic roughness of the city.

In sum, a city's effect on its own climate is complex and far reaching. Questions of the significance and desirability of the weather changes wrought by urbanization have only recently been considered. Since some of the urban-induced changes have occurred gradually they have been difficult to measure



quantitatively and therefore unrecognized by the urban dweller. Now that urbanization is nearly universal, many urban dwellers have suddenly become aware of numerous urban-induced weather changes.

In general, the urban-induced changes in weather types are considered highly undesirable. Such changes include increased contaminants, higher warm-season temperatures, lower winds, added fog and decreased visibility. However, certain urban related weather changes are desirable, including increased temperatures in winter, and additional rainfall to cleanse the air and increased precipitation in downwind agricultural areas.

The spatial extent of an urban area's alterations of weather and climate is limited. Many of the changes are truly local and exist largely within the complex and a few hundred feet above it. A few other changes, particularly to visibility, clouds and rainfall, often extend 30 to 50 miles downwind and produce mesoscale changes. The effects of inadvertent urban-related precipitation increases have long been realized in surface runoff, and in agricultural production and groundwater quality.

The most significant question relating to urban effects on weather concerns the potential combined effects of growing megalopolises. Will they only be additive or is it possible they will trigger changes in macroscale or even global weather?

APPENDIX C

Embedded Picture Condition

DIRECTIONS

You will have twenty minutes (20) in which to study the following passage entitled 'The Urban Climate'. The passage is eleven (11) typewritten pages long.

Pay particular attention to the illustrations embedded in the passage, and refer to them while you are reading. They have been designed to assist you in remembering and comprehending the print material.

Please attend to the passage very carefully, because you will be asked to write down as much as you can remember from the passage once you have finished. The final task is a twenty-five (25) item multiple-choice test which will assess how well you understood and remembered the information contained in the illustrations and in the passage.

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PLEASE DO NOT TURN THE PAGE  
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## The Urban Climate

If the object of building construction is to create an artificial climatic environment in which the optimum physiologic needs of man are met, then it has been highly successful. Given present day technology and sufficient funds, it is possible to produce an interior environment in which light, heat and humidity conditions can be regulated to meet any contingency. The construction of such an internal environment however, cannot be achieved without modifications of the pre-existing external conditions and as a by-product of meeting human living requirements, a new set of climatic conditions are created.

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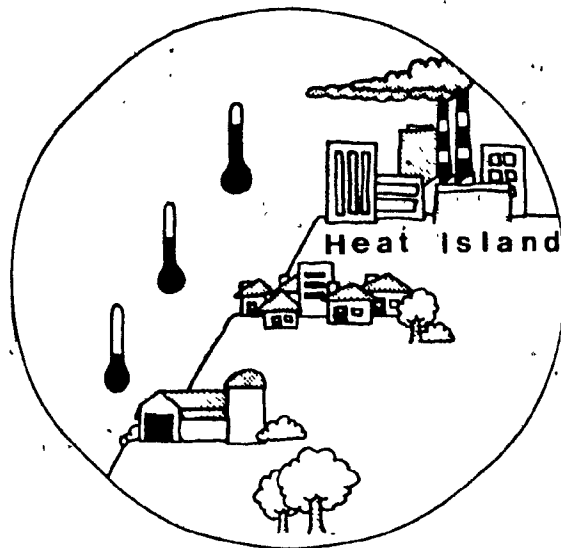
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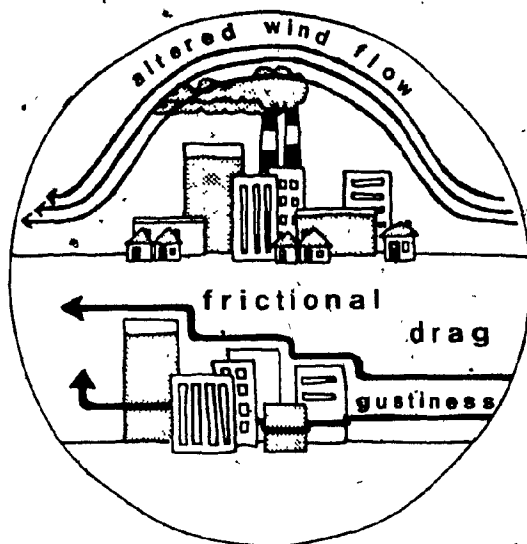


(REFER TO PICTURE) of a large city will generally show a plateau of elevated temperatures, which slopes gently away from the center, surrounded by a heat cliff in the suburban regions where the

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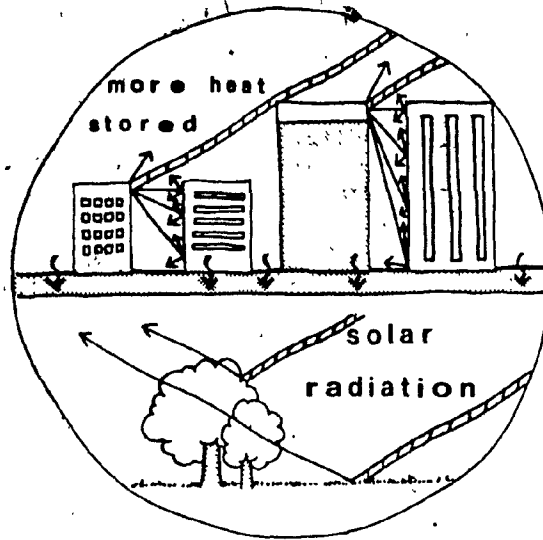
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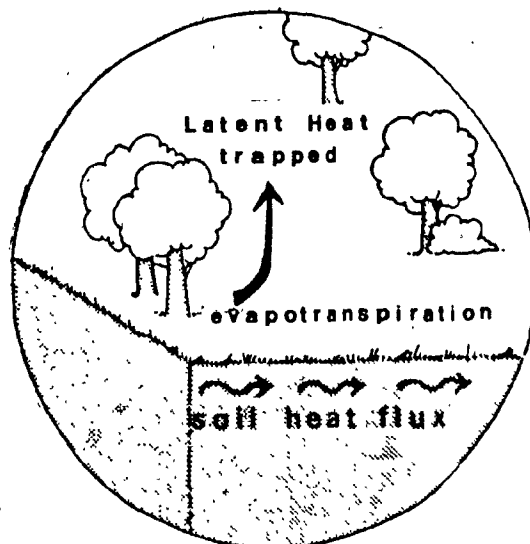




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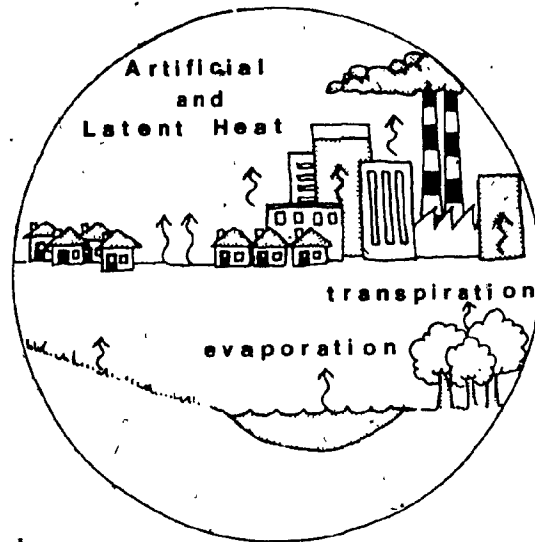
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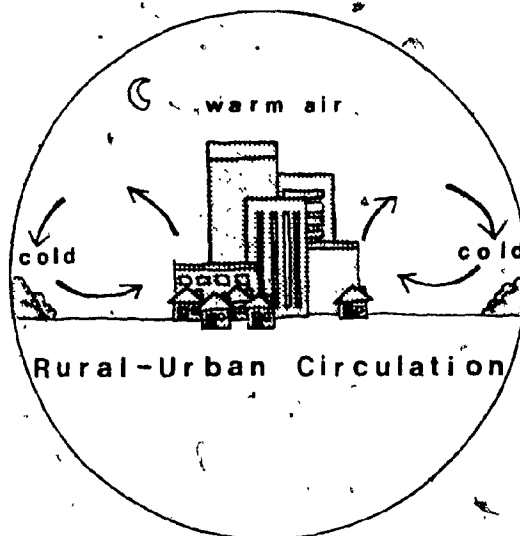
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APPENDIX D

Control

DIRECTIONS

You will have twenty minutes (20) in which to study the following passage entitled 'The Urban Climate'. The passage is eight (8) typewritten pages long.

Please attend to the passage very carefully, because you will be asked to write down as much as you can remember from the passage once you have finished. The final task is a twenty-five (25) item multiple choice test which will assess how well you understood and remembered the information contained in the passage.

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PLEASE DO NOT TURN THE PAGE  
UNTIL INSTRUCTED TO DO SO.



## The Urban Climate

If the object of building construction is to create an artificial climatic environment in which the optimum physiologic needs of man are met, then it has been highly successful. Given present day technology and sufficient funds, it is possible to produce an interior environment in which light, heat and humidity conditions can be regulated to meet any contingency. The construction of such an internal environment however, cannot be achieved without modifications of the pre-existing external conditions and as a by-product of meeting human living requirements, a new set of climatic conditions are created.

Buildings that are designed for control of their internal climates also affect the microclimates in their vicinities by influencing air movement, heat exchange, and moisture flux. Anyone who has contrasted the microenvironment over a hot pavement with that over a green lawn has a practical appreciation of man's influence. Roads are commonly drier than adjacent land, have a lower albedo and are more likely to be travelled by sources of atmospheric pollutants. The construction of an embankment across a small valley can disrupt air flow and create a distribution of temperature that is reflected in the composition of plant communities. The effects of factories, parks and swamp drainage are additional random examples that illustrate the ways in which man and his works modify climate on a small scale. Any change in albedo, water capacity and retention, evaporation, transpiration,

or surface roughness may produce a change in climate, but the results are complex, difficult to measure and not easily predicted.

The city, like its surrounding countryside, is immersed in the lower layers of the earth's atmosphere, and it is the properties and behavior of this fluid and the way the city shares its energy with the atmosphere that provide the dominant link between man's urban activities and the climate he lives in.

The individuality of any climate relates to the flux of energy that arrives at a surface and the manner of its subsequent distribution. The amount of energy received at a surface depends upon earth-sun relationships together with the way in which the solar beam is modified as it passes through the atmosphere or is reflected from the surface.

On an annual average, downtown urban temperatures at or near the surface are characteristically higher than in the surrounding countryside. This annually averaged difference is typically of the order of  $1^{\circ}$  F. but depends on the size of the city, the latitude, and the amount of energy conversion. The strongest contribution to this annual average comes from "fair weather" situations, in which the city and the countryside both warmup during the day, but the countryside cools off more rapidly. By late afternoon or early evening the city has become definitely warmer by comparison, and the magnitude of the temperature difference continues to grow for some time after sunset. This passive differential cooling mechanism can be aided considerably by

artificial energy released within the urban complex. Heat generated by domestic space heating, transportation and industrial activities dominates the winter energy budgets of many northern cities and leads to the formation of strong 'heat islands' on clear winter nights.

In summer and early autumn, heat islands are sometimes barely detectable during the day but often exhibit temperature excesses of  $10^{\circ}$  F. or more, which strongly affect the annual average. Winter heat islands exhibit a weaker variation but can show more extreme urban-rural differences. The heat island of a large city will generally show a plateau of elevated temperatures, which slopes gently away from the center, surrounded by a heat cliff in the suburban regions where the temperatures fall off rapidly to match those of the surrounding countryside. The plateau will exhibit local maxima corresponding to energy-intensive industry, and the cliff will be eroded by local topographic effects due to local valley drainage winds and lake or sea breezes. The amount of warming which occurs with a heat island correlates with a city's growth rate. In consequence, as the heat island expands and intensifies, stronger and stronger regional winds are needed to overcome it and dissipate the heat beyond the city. However, it is unwise to consider the heat island of surface temperature excess without considering the way in which the city shares its energy with the atmosphere boundary layer in which it is immersed.

Net radiation is a term used to describe a heat gain by day and a heat loss by night in both the city and the surrounding countryside. Solar radiation over the city is markedly weakened by having to penetrate the pollution haze ( and hence tends to be strongest at weekends, when there is less pollution ). About 80% of the solid contaminants in the urban atmosphere are in the form of particles that are small enough to remain suspended for several days. Although these particles collectively tend to reflect solar radiation, thereby reducing the amount of radiation reaching the surface, they also tend to retard the out-flow of heat.

The varied geometry of a city skyline introduces a high degree of surface roughness into the landscape which exceeds that of most rural areas. The chief impact of this (aerodynamic) roughness is on the air flowing over the urban surface, so that mechanical turbulence is set up. The total effect of this frictional drag is to reduce windspeeds within the built-up area, although localized turbulence and eddying leads to marked increases and gustiness under certain conditions. With increasing roughness the height of the windlayer affected also increases. Investigations suggest that the roughness increases with the width of the building and the square of its height, but is inversely proportional to the size of the lot occupied by the building. Radiation from below also causes the heat island to act as a mound barrier to surface air flow. This also proportionately lengthens the time required for the wind to flush air pollutants from the city.

Different surfaces also have different reflective characteristics and the city comprises a multitude of surface varieties which function like a maze of reflectors, absorbing some of the energy they receive and directing much of the rest to other absorbing surfaces. It is also note-worthy that the vertical extent of city buildings will further cause the overall amount of reflection possible to vary markedly even within the city and to continue even while the sun is low in the sky.

Modification of a surface can also modify the net radiation by altering the albedo. The city has a lower albedo because of the darkly coloured streets, so that it absorbs solar radiation better. The greater thermal conductivity of the urban fabric results in a considerably enhanced storage of heat. The soil heat flux is a surface loss by day and a gain by night in both environments. In the city however, this flux is partly replaced by fluxes into and out of the concrete and tarmac of roads and buildings, therefore, they have a higher heat capacity than the soil of rural areas.

In rural areas, the ground receives heat during the day and cools off during the night, but vegetation acts as an insulating blanket ( in large part by trapping still air through which heat moves slowly ). The soil heat flux contained in the ground is therefore reduced. During the day, the grass blanket keeps heat from flowing into the ground as rapidly, so there is less heat stored in the soil. This would leave more at the

surface to heat the air except that evapotranspiration from the vegetation helps to lower temperatures. At night, the temperature at the top of the grass drops owing to re-radiation back to the atmosphere, but the insulating blanket prevents considerable heat flow from the soil below.

The rapid runoff of rainfall caused by the imperviousness of the surfaces of roads and roofs as well as by the drainage system is another major effect of cities. This waterproofing involves a hydrologic change with climatic consequences. Except in limited green areas and parks, the pathways taken by moisture is quite limited in the city. Transpiration, infiltration (to both ground and soil water) and evaporation are radically reduced. The amount of surface standing water is reduced to a minimum with the result that energy available for latent heat is increased significantly. This is significant because the evaporation process removes heat from the air ( approximately 600 calories for every gram of water evaporated ) and hence has a cooling effect at the earth's surface.

However, it must be noted that the production of water vapor and steam as a by-product of various combustion processes are indigenous to the urban environment. The artificial heat source is dependent on the release of waste heat by domestic furnaces, industries, car and other vehicles, and a variety of other sources. The amount of heat released is considerable. In the urbanized areas the rejected energy has already become a measurable fraction of the energy received from the sun at the surface of the earth.

The heat island is not merely a surface effect. A few hundred meters of the atmospheric boundary layer are also heated and special wind effects are sometimes observed. One such immediate consequence of the heat island is increased convection over cities, especially in the daytime. This has been beautifully demonstrated by the lift given to constant-volume balloons that have been launched across cities. The up-draft leads, together with the large amount of water vapor released by combustion processes and steam power, to increased cloudiness over cities. It is also a potent factor in the increased rainfall reported from cities. Even at night the heating from below will counteract the radiative cooling and produce a positive temperature lapse rate (temperature which increases with increasing altitude), while at the same time inversions form over the undisturbed countryside. This together with the surface temperature gradient, creates a pressure field which will set a concentric country breeze in motion. This localized rural-urban circulation pattern does not accelerate because the buoyant lift of rising warm air is balanced by friction due to the aerodynamic roughness of the city.

In sum, a city's effect on its own climate is complex and far reaching. Questions of the significance and desirability of the weather changes wrought by urbanization have only recently been considered. Since some of the urban-induced changes have occurred gradually they have been difficult to measure quantitatively and therefore unrecognized by the urban dweller.

Now that urbanization is nearly universal, many urban dwellers have suddenly become aware of numerous urban-induced weather changes.

In general, the urban-induced changes in weather types are considered highly undesirable. Such changes include increased contaminants, higher warm-season temperatures, lower winds, added fog and decreased visibility. However, certain urban related weather changes are desirable, including increased temperatures in winter, and additional rainfall to cleanse the air and increased precipitation in downwind agricultural areas.

The spatial extent of an urban area's alterations of weather and climate is limited. Many of the changes are truly local and exist largely within the complex and a few hundred feet above it. A few other changes, particularly to visibility, clouds and rainfall, often extend 30 to 50 miles downwind and produce mesoscale changes. The effects of inadvertent urban-related precipitation increases have been realized in surface runoff, and in agricultural production and groundwater quality.

The most significant question relating to urban effects on weather concerns the potential combined effects of growing megalopolises. Will they only be additive or is it possible they will trigger changes in macroscale or even global weather?



APPENDIX E.  
Multiple Choice Test

## TEST DIRECTIONS

This test consists of twenty-five (25) multiple choice questions which were derived from the article.

You should find an answer sheet included in the envelope. You are asked to use this sheet to respond to the questions.

Please answer all questions. If you don't know or are unsure which of the options is the correct one, you are asked to select the one which you believe is most likely to be correct.

## EXAMPLE:

Q # 1. The Prime Minister of Canada is named:

- a. John Denver
- b. Margaret Thatcher
- c. Pierre Trudeau
- d. Margaret Trudeau

Clearly, the correct answer is (c) and you would indicate this by circling (c) beside the appropriate question on your answer sheet:

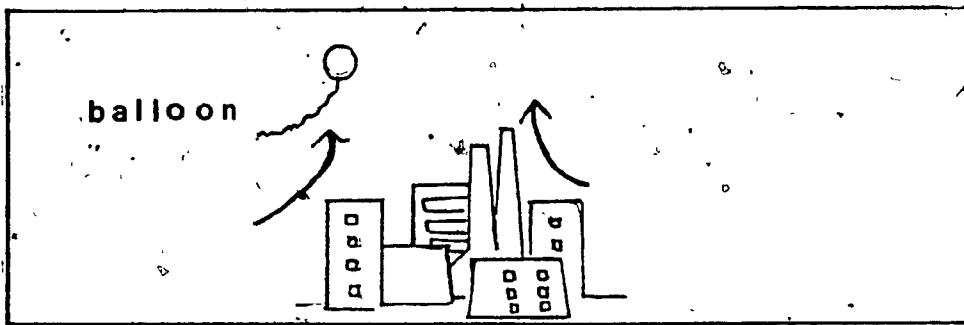
1. A B  C D

Should you make a mistake and wish to change your answer, simply cross out your original selection with an "X" and then circle your new choice:

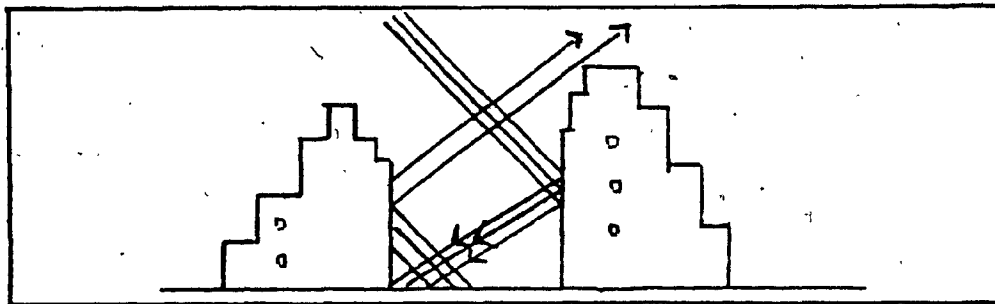
1.  A B  C D

Before you begin.... DO YOU HAVE ANY QUESTIONS?

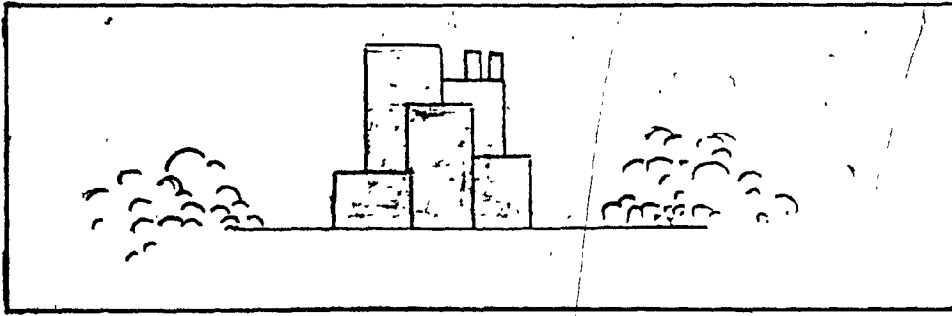
1. What role does vegetation play in reducing the soil heat flux in rural areas?
  - a. it absorbs heat at greater depths so less is available at the surface to heat the air
  - b. solar radiation is more easily reflected from the surface
  - c. retards heat absorption and heat release
  - d. traps water vapour which cools the air



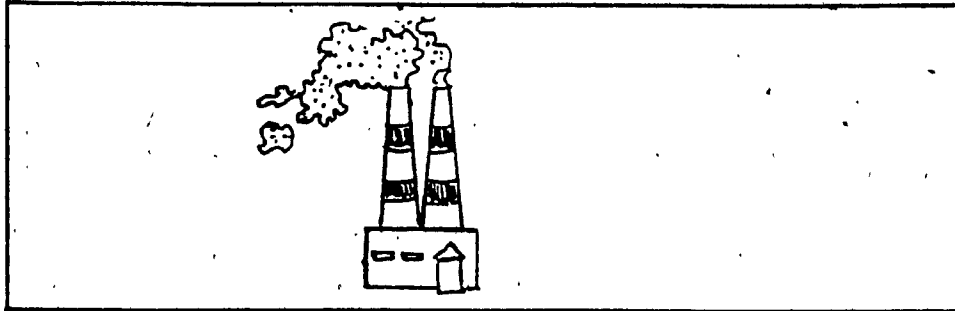
2. The picture above best illustrates:
  - a. air turbulence
  - b. urban circulation pattern
  - c. positive lapse rate
  - d. convection
3. Urbanization modifies climate principally by changing:
  - a. precipitation patterns
  - b. vertical wind distribution
  - c. the heat balance
  - d. the natural environment



4. The shape and orientation of the above surfaces have a strong bearing on the climate because:
- a. radiation tends to be reflected back to the sky
  - b. any tendency for upward movement of air in the space between buildings is inhibited
  - c. vertical walls tend to reflect solar radiation towards the ground
  - d. heat retained in concrete buildings causes air temperature to increase
5. The solid contaminants found suspended in the pollution haze located over cities are made up of what percentage of particles?
- a. 80%
  - b. 78%
  - c. 70%
  - d. 68%

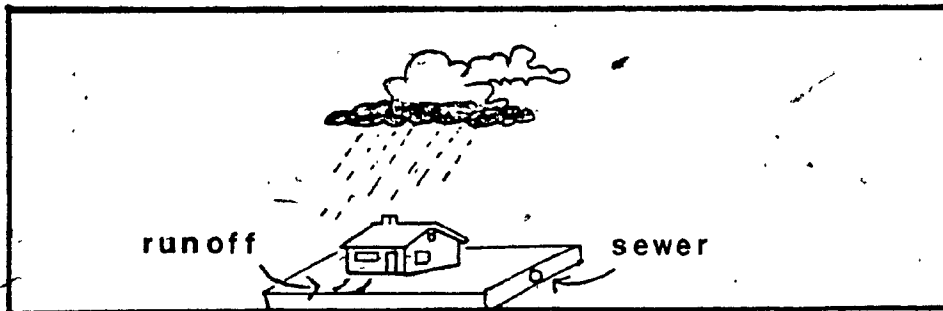


6. You are out for an evening stroll, you notice the city in the distance bordered by the countryside. The wind this evening happens to be light. Given this information, what do you think is occurring?
- warm air front
  - increased convection
  - concentric country breeze
  - a fair weather situation
7. In mid and high latitudes during the winter, the major source of heat in many cities is:
- solar energy
  - artificial energy
  - warm air inversions
  - latent heat
8. An experiment has demonstrated that when a snow or ice surface is covered with a thin layer of black material the energy balance is so modified that the snow will melt. What exactly has been altered?
- soil ground flux
  - insolation
  - albedo
  - net radiation

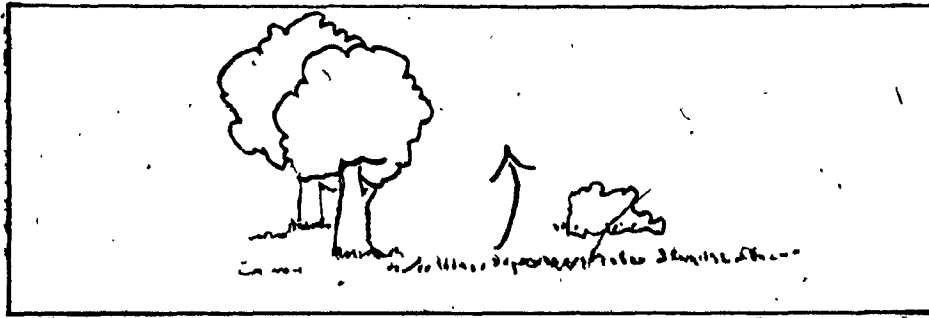


9. What major contribution (s) does this illustration play in altering the urban climate?
- it is built of material that has a different energy balance in comparison to the rural fabric
  - releases excessive amounts of water vapour into the atmosphere
  - one of several elements which contributes to an artificial release of energy into the atmosphere
  - all of the above
10. The heat island is in some cases an entirely favourable effect, especially when:
- industry is located down wind from the city
  - cities are located in low latitudes
  - industry is located adjacent to wind drainage valleys
  - cities are located in high latitudes
11. The contrast between urban and rural surfaces shows the greatest difference in reflectivity and absorption of radiation:
- early in the morning
  - mid-day
  - early evening
  - at sunset

12. The effect of frictional drag in the downtown area of a large city results in:
- wind speed being lowered
  - increased surface roughness
  - pollution count is lowered
  - heat island expansion

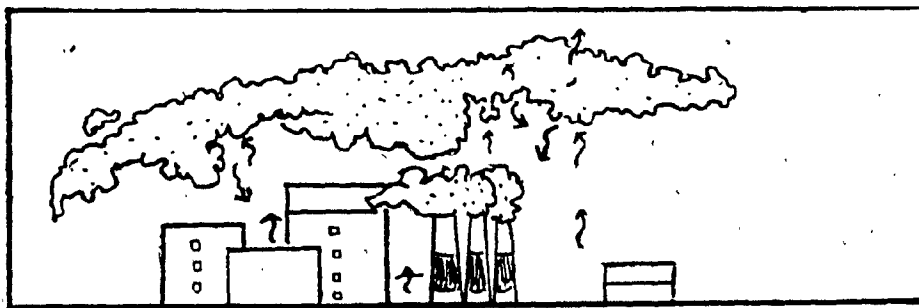


13. Consider the above illustration, what obvious effect is it having on the environment?
- an aerodynamic effect
  - a thermal effect
  - a mesoscale effect
  - a hydrologic effect
14. A temperature build-up within the urban area is often referred to as:
- heat island
  - moisture flux
  - heat sink
  - latent heat

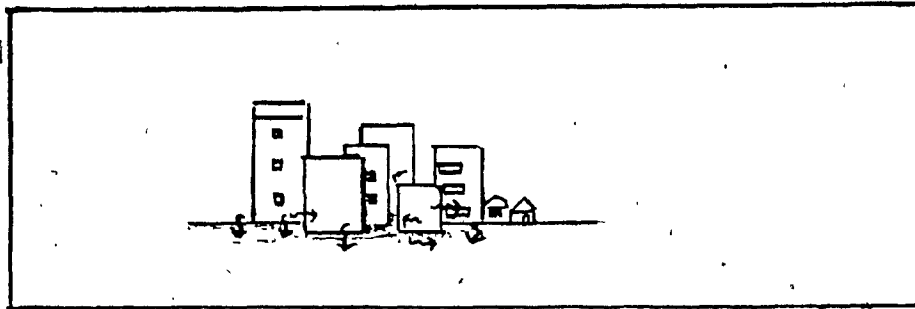


15. The process where-by surface vegetation lowers the air temperature is called:
- transpiration
  - evaporation
  - evapotranspiration
  - root respiration
16. With decreasing roughness, the height of the affected wind layer:
- remains the same
  - increases
  - decreases
  - none of the above
17. Which of the following processes are not reduced in the urban environment?
- transpiration
  - evaporation
  - infiltration
  - precipitation



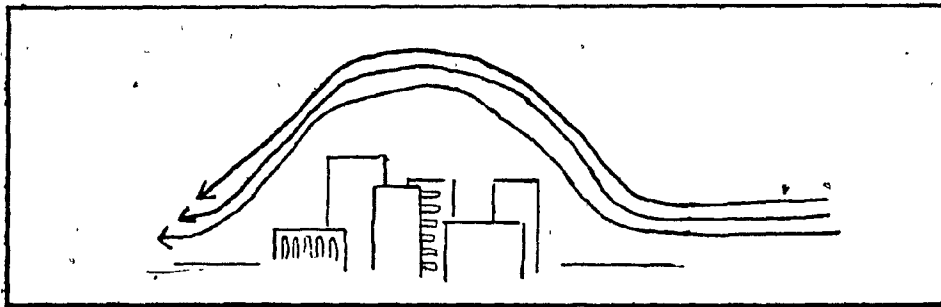


18. This picture best illustrates:
- the pollutants added to the atmosphere retard the outgoing radiation
  - atmospheric boundary layers of this kind are present over all cities
  - radiative cooling from the ground chills the base of the boundary layer
  - because a city is warmer it loses more heat by upward long-wave radiation
19. The urban heat balance has a profound effect on the:
- artificial heat
  - circulation of air
  - agricultural growing season
  - change in albedo
20. You are spending a hot summer afternoon in mid-town Manhattan. Aside from the more obvious crime related hazards, what other hazard is present?
- heat stroke
  - sunburn due to increased ultraviolet radiation
  - bronchitis due to exhaust fumes from traffic
  - none of the above



21. The heat emanating from the buildings and roads contributes directly to the:
- a. humidity in the air
  - b. soil heat flux
  - c. amount of latent heat
  - d. mechanical turbulence
22. This summer you've decided to have an outdoor dinner party for an albino friend. Since your friend is particularly sensitive to light, you'll be serving dinner at 7 p.m. on a rooftop terrace of a building located next to a skyscraper. However, a wiser friend chides you on your choice of location because:
- a. the building is situated downtown, so there is bound to be a heat island effect
  - b. the sudden strong gusts of wind will become a nuisance
  - c. there is still a great deal of light being reflected off the skyscraper
  - d. there is enough sunlight such that your friend could still receive a bad sunburn

23. It is late afternoon in Montreal, where would the highest temperature of the heat island be found?
- a. Beaver lake
  - b. Dorval airport
  - c. Place Ville Marie
  - d. Point St. Charles
24. Which season would one find the largest temperature difference between the city and the countryside?
- a. Spring
  - b. Summer
  - c. Fall
  - d. Winter



25. What is taking place in this illustration?
- a. it illustrates the concept that the heat island is not merely a surface effect.
  - b. the wind is dispersing the warmth from the city downwind.
  - c. the urban heat island acts as a mound barrier to surface air flow.
  - d. despite the strong winds, the urban heat island continues to grow in intensity.

ANSWER SHEET

STUDENT No. \_\_\_\_\_

## QUESTION

No.

- |     |   |   |   |   |     |   |   |   |   |
|-----|---|---|---|---|-----|---|---|---|---|
| 1.  | A | B | C | D | 13. | A | B | C | D |
| 2.  | A | B | C | D | 14. | A | B | C | D |
| 3.  | A | B | C | D | 15. | A | B | C | D |
| 4.  | A | B | C | D | 16. | A | B | C | D |
| 5.  | A | B | C | D | 17. | A | B | C | D |
| 6.  | A | B | C | D | 18. | A | B | C | D |
| 7.  | A | B | C | D | 19. | A | B | C | D |
| 8.  | A | B | C | D | 20. | A | B | C | D |
| 9.  | A | B | C | D | 21. | A | B | C | D |
| 10. | A | B | C | D | 22. | A | B | C | D |
| 11. | A | B | C | D | 23. | A | B | C | D |
| 12. | A | B | C | D | 24. | A | B | C | D |
| 25. |   |   |   |   | A   | B | C | D |   |

WHAT IS YOUR MAJOR? \_\_\_\_\_

APPENDIX F  
Free Recall Test

TEST - Part 1

Let us assume that the reading of the article "THE URBAN CLIMATE" was an in-class assignment on a course that you are now taking. Let us also assume that, before this class, one of your friends advised you that she would be unable to make it but wanted you to be able to tell her about it so that she would not fall behind.

Please write down here, in complete sentences, all that you can remember from the passage so that you would be able to provide a thorough briefing about the contents when your friend returned.

APPENDIX G

Idea Units

## (The Urban Climate)

(If the object of building construction is to create an artificial climatic environment)(in which the optimum physiologic needs of man are met,))(then it has been (highly) successful.) (Given present day technology and sufficient funds,))(it is possible to produce an interior environment)(in which light,)(heat and (humidity conditions)(can be regulated to meet any contingency.) (The construction of such an internal environment however,)(cannot be achieved without modifications of the pre-existing external conditions) and (as a by-product of meeting human living requirements,))(a new set of climatic conditions are created.)

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(or surface roughness)(may produce a change in climate)(but the results are complex)(difficult to measure) and (not easily predicted.)

(The city, like its surrounding countryside)(is immersed in the lower layers of the earth's atmosphere)(and it is the properties and behavior of this fluid) and (the way the city shares its energy with the atmosphere)(that provide the dominant link)(between man's urban activities)(and the climate he lives in.)

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(The varied geometry of a city skyline) (introduces a high degree of surface roughness into the landscape) (which exceeds that of most rural areas.) (The chief impact) (of this (aerodynamic) roughness) (is on the air flowing over the urban surface,) (so that mechanical turbulence is set up.) (The total effect) (of this frictional drag) (is to reduce windspeeds within the built-up area,) (although localized turbulence and eddying) (leads to marked increases and gustiness) (under certain conditions.) (With increasing roughness) (the height of the windlayer affected also increases.) (Investigations) (suggest that the roughness increases with the width of the building) (and the square of its height,) (but is inversely proportional to the size of the lot occupied by the building.) (Radiation) (from below) (also causes the heat island) (to act as a mound barrier) (to surface air flow.) (This also proportionately) (lengthens the time required for the wind to flush air pollutants) (from the city.)

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(However, it must be noted that the production of water vapor and steam)(as a by-product of various combustion processes)(are indigenous to the urban environment.) (The artificial heat source)(is dependent on the release of waste heat)(by domestic furnaces,)(industries,)(car) and(other vehicles,)(and a variety of other sources.) (The amount of heat released)(is considerable.) (In the urbanized areas)(the rejected energy)(has already become a measurable fraction of the energy)(received from the sun)(at the surface of the earth.)

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(In sum, a city's effect on its own climate)(is complex and far reaching.) (Questions of the significance and desirability of the weather changes)(wrought by urbanization)(have (only recently) been considered.) (Since some of the urban-induced changes) (have occurred gradually)(they have been difficult to measure quantitatively) and (therefore unrecognized by the urban dweller.)

(Now that urbanization is (nearly) universal,) (many urban dwellers) (have suddenly become aware) (of numerous urban-induced weather changes.)

(In general, the urban-induced changes in weather types) (are considered highly undesirable.) (Such changes include) (increased contaminants,) (higher warm-season temperatures,) (lower winds,) (added fog) (and decreased visibility.) (However, certain urban related weather changes are desirable) (including increased temperatures) (in winter,) (and additional rainfall) (to cleanse the air) and (increased precipitation) (in (downwind) agricultural areas.)

(The spatial extent of an urban area's alterations of weather and climate) (is limited.) (Many of the changes) (are truly local) (and exist largely within the complex) (and a few hundred feet above it.) (A few other changes,) (particularly to visibility) (clouds) (and rainfall,) (often extend 30 to 50 miles downwind) and (produce mesoscale changes.) (The effects of (inadvertent) urban-related precipitation increases) (have been realized in surface runoff,) and (in agricultural production) and (groundwater quality)

(The most significant question) (relating to urban effects on weather) (concerns the potential combined effects of (growing) megalopolises.) (Will they only be additive) or (is it possible they will trigger changes in macroscale) (or even global weather?)

APPENDIX H  
Interpolated Task



Math Quiz

Please carry out the following arithmetic calculations  
(without calculator!) :

1. Add:

16	45	251	2117
<u>  9</u>	<u> 15</u>	<u>386</u>	<u>1973</u>

2. Subtract:

- (a) 15 from 27 ?
- (b) 19 from 15 ?
- (c) 75 from 139?
- (d) 10 from 5 ?

_____
_____
_____
_____

3. Multiply:

- (a) 16 by 10 ?
- (b) 15 by 5 ?
- (c) 110 by 10?
- (d) 136 by 24?

_____
_____
_____
_____

4. Divide:

- (a) 45 by 9 ? \_\_\_\_\_
- (b) 2482 by 24 ? \_\_\_\_\_

