THE USE OF CONCEPT MAPS AS ADVANCE ORGANIZERS IN GRADE SEVEN SCIENCE

by

Michael Arthur O'Leary

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The undersigned certify that they have read, and recommended to the Faculty of Education for acceptance, a thesis entitled **THE USE OF CONCEPT MAPS AS ADVANCE ORGANIZERS IN GRADE SEVEN SCIENCE** submitted by **MICHAEL ARTHUR O'LEARY** in partial fulfillment of the requirements for the degree of **MASTER OF ARTS IN EDUCATION.**

Bernard [illegible]

[illegible]

(Supervisors)

[illegible]

(Dean of Education)

DATE: 25 April 1994

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RELEASE FORM

NAME OF AUTHOR: **MICHAEL ARTHUR O'LEARY**

TITLE OF THESIS: **THE USE OF CONCEPT MAPS AS ADVANCE ORGANIZERS IN GRADE SEVEN SCIENCE**

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Michael A. O'Leary

110 Lakeview Road
Windsor Junction, Nova Scotia
Canada
B0N 2V0

Phone: 902 861 - 4157

DATE: April 25 / 94

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ABSTRACT

THE USE OF CONCEPT MAPS AS ADVANCE ORGANIZERS IN GRADE SEVEN SCIENCE

Concept maps are heuristics for visually representing conceptual systems. The technique is generally associated with Ausubelian views of learning and cognition. The device has potential for use as an advance organizer type of preinstruction. This study compared two systems for organizing and presenting science material: the traditional method as prescribed by the textbook, and an Ausubelian approach that integrates concept maps as advance organizers.

Eighty-nine grade seven students in four classes took part in the study. Pretest scores showed all participating classes were equal. For research purposes, the four classes were then divided into two groups: control (N = 45) and organizer (N = 44).

Organizer group subjects received concept maps and brief oral presentations before lessons. Control group subjects received no preinstruction. Lesson content was the same for both treatment groups. Both groups received six weeks of instruction. A pretest and posttest determined if there was a significant difference between the groups. After the first unit the experimental and control groups were reversed. During the first six-week unit on Living Things, the organizer group scored

significantly higher (p =.0195) than the control group. After the second six-week unit on Solutions, similar results were found (p = .013) in favor of the experimental group using a concept map as an advance organizer.

The results of this study found almost a 10% increase in learning of science material. It is concluded that using concept maps as advance organizers for organizing and presenting material is a valid metacognitive heuristic for improving meaningful learning in science.

Michael Arthur O'Leary

April 5, 1994

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INTRODUCTION

MEANINGFUL LEARNING / ADVANCE ORGANIZERS

"Teaching is one of the most complex human endeavors imaginable" (Sapier & Gower, 1987, p. 3). Educators are becoming increasingly aware of the various teaching strategies that can enhance learning. A great deal of research has focused on the creation and identification of a variety of teaching strategies. Brandt (1985) noted the search for alternatives to conventional didactic instruction followed by classroom practice led to research into strategies suitable for various instructional purposes. Strong, Silver, and Hanson (1985) described a teaching strategy as "the teachers plan for moving learners toward a curriculum objective" (p. 10).

Joyce, Weil, and Wald (1973); Joyce (1980); Joyce and Weil (1986) identified over 80 teaching strategies that were in turn categorized into four main models:

1. Social Interaction Models

Emphasize the relationships of the individual to society and other persons. The goal is to improve the individual's ability to relate to another and to work productively in society.

2. Personal Models

Are used to help students develop into capable individuals that are able to interact with their environment and foster good interpersonal relations.

3. Behavior Modification and Cybernetic Models

Seek to sequence learning tasks and shape behavior by manipulation of reinforcement.

4. Information-Processing Models

Aim at the information-processing capability of students and how they can process and retain information.

The information processing family of models addresses the ways students can improve their ability to master information, including capacities to organize data, generate concepts, and solve problems.

Eggan and Kauchak (1988) recognized information processing can be thought of as the way people gather and organize information, which also requires a direct and active teacher guiding the learning activities. One such information-processing model which has received a great deal of attention and research over the last thirty years is the advance organizer developed by David Ausubel (1963). This teaching model is based on his theory of meaningful learning and has a distinct set of steps or phases created to achieve certain outcomes.

Meaningful learning (Ausubel, Sullivan, & Ives, 1980) involves the relation of new ideas to relevant, established ideas. This explicit relationship ensures that a greater quantity of material is incorporated more easily and made more available immediately after learning. The new idea will share in some of the stability of the older established ideas and hence be retained longer.

In the book *Theory and Problems of Adolescent Development*, Ausubel, Montemayor, and Svajian (1977) regard learning as more meaningful when it proceeds from lower to higher degrees of differentation, when a student starts with a general conceptual overview that furnishes orientation and direction and then works backwards filling in details, specifics, and supporting evidence.

An important factor in generating clear and stable meanings is the achievement of a proper balance between concepts and their supporting data. Concepts that cannot be related to illustrative experience or relevant examples soon become meaningless words. Farmer and Farrell (1980) have found that the meaning of the material has been shown to be the prime factor associated with retention (remembering) of subject matter over time. Ausubel (1968) proposes that new content becomes meaningful to the extent that it is substantively (nonarbitrarily) related to ideas existing in the cognitive structure of the learner. Rakow (1992) agrees, stating, "previous experiences are the hooks upon which new learning is hung" (p. 18).

Education theorist David Ausubel (1968) in his book *Educational Psychology: A Cognitive Approach* stated: "If we had to reduce educational psychology to just one principle, we would say: The most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly" (p. vi). The impact this quote had on pedagogy is profound. What this statement means is that we must first find out the relevant ideas the student already possesses about a certain topic, then, having ascertained this, teach in such a way that new information is linked with existing concepts. It is incumbent upon the teacher to find the means for students to deal with the subject matter. One such means for the students to deal with the subject matter in a meaningful way is the advance organizer.

Ausubel (1960, 1963) developed advance organizers to orient students to material that they are about to learn and to help them recall related information that could be used to assist in incorporating the new information. In essence the advance organizer is based on the precept that material which is well organized is much easier to learn and remember than material that is poorly organized.

The advance organizer is a deliberately prepared set of ideas which are presented to the learner in advance of learning new material. The principal function is to bridge the gap between what the learner already knows and what he needs to know before he can meaningfully learn the task at hand. To be useful, however, organizers must themselves be learnable and must be stated in familiar terms (Ausubel, Novak, and Hanesian, 1978, p. 171-173). Ausubel described advance organizers in this way:

> I define advance organizers as introductory material at a higher level of abstraction, generality, and inclusiveness than the learning passage itself, and an overview as a summary presentation of the principal ideas in a passage that is not necessarily written at a higher level of abstraction, generality, and inclusiveness, but achieves its effect largely by the simple omission of specific detail (Ausubel, 1978, p. 252).

Ausubel claimed the success of advance organizers depended upon three functions or processes, subsumption, progressive differentiation, and integrative reconciliation.

Critical to the application of advance organizers is the subsumption process. Ausubel (1968) assumed that concepts an be hierarchically organized in terms of highly inclusive concepts (superordinate) under which are subsumed less inclusive concepts (subordinate). Thus, each concept is linked to the next higher step in the hierarchy through the process called subsumption.

Likewise, in the process of progressive differentiation, the more general and inclusive ideas or concepts are presented first then broken down into smaller related parts. Ausubel, Novak, and Hanesian (1978) claim anyone who pauses long enough to give the problem some serious thought cannot escape the conclusion that we live in a world of concepts rather than in a world of objects, events, and situations. Ausubel recommends the teacher present the material to be learned in such a way that the most general ideas are presented first and then followed by gradual increases in detail and specificity.

Additionally, the teacher consciously attempts to highlight relationships between the concepts or ideas in the advance organizer. This is called integrative reconciliation. These relationships can be similarities or differences that are made explicit in order to make connections between the concepts and ultimately give more meaning to the new material.

The advance organizer is designed to strengthen cognitive structures of a person's knowledge or a particular subject matter. Its strength comes from the way material is presented and how well it is organized to facilitate material acquisition and retention. One of Ausubel's assumptions is that there should exist a parallel between the way subject material is organized and the way people organize knowledge in their minds (cognitive structures).

The use of advance organizers and meaningful learning fits a constructivist's learning point of view. This constructivist view of education is based on the assumption that knowledge is dependent upon the integration and growth of concepts that already exist in the person's cognitive framework, and that new information is actively assimilated and related to relevant concepts.

According to Braathan (1988) the constructivist's view of learning is that people construct their view of the world throughout their lifetime.

Throughout life this view of the world undergoes a qualitative and quantitative change. Hence, learning is an active process of construction and reconstruction of knowledge and is influenced by existing conceptions or views.

Jonassen (1982) in his text, *The Technology of Text* , related to advance organizers usefulness for knowledge building as, "You cannot add a new room on to your house until you have built the frame (foundation)" (p. 258). Slavin (1988) said the purpose of using advance organizers before a lesson is to provide students with "scaffolding" on which to build new understanding (p. 186). This scaffolding consists of both information already in students' minds and new concepts or principles that can organize this information in a form that will help in new learning.

There are two types of advance organizers as proposed by Ausubel (1968):

1. Expository organizers present the basic concepts, which provide the intellectual scaffolding to which new information can be linked or connected. For example, one would learn about trees in general before proceeding to the different kinds or types of trees.
2. Comparative organizers are used with relatively familiar material and are used to compare or discriminate between already learned and new material. For example, after a unit about reproduction in flowering plants, the similarities and differences with human reproduction can be discussed. This facilitates the relationship of both to sexual reproduction while some distinct differences are also noticed.

Ausubel recommends advance organizers to complement reception learning. In reception learning the teacher structures the learning situation by presenting the materials in well organized lessons that meet the basic criteria of advance organizer presentation. Ausubel contends that reception learning has and will continue to be the dominant form of learning in school (Ausubel 1963, p. 83). "In this type of learning, new meanings are typically acquired in relation to hierarchically organized, existing bodies of knowledge in the learner" (Ausubel, 1967, p. 28). At the heart of this approach is what Ausubel calls expository teaching (teacher-planned, systematic instruction). Farmer and Farrell (1980) have found making content meaningful to the learner is a two-edged sword. The teacher must consider characteristics of the content as well as the match between the new content and the student's existing mental structure.

There are two dimensions to the learning process: the means by which the knowledge is made available to the learner and the way the learner may incorporate the knowledge into existing structures of ideas. This incorporation - to retain the idea by linking it to what they already know - is known as meaningful learning. Meaningful reception learning occurs when the teacher presents the generalization in its final form, and the learner relates it to existing ideas in some way (Anderson, and Ausubel, 1965; Ausubel, and Robinson, 1969).

Joseph Novak (Novak & Gowin, 1984), a major figure in the field of science education, said: "Ausubel's theory is specifically addressed to concept learning" (p. 94). "Concepts are what people think with" (p. 201). After studying advance organizers, Novak thought of them in this way:

> Advance organizers function only when new materials are inherently meaningful and some rudimentary concept relevant to the new material already exists in the learner's cognitive structure. Under these

> circumstances, the advance organizer can serve as a cognitive bridge, which links new information to be learned to existing, relevant concepts in cognitive structure and this facilitated learning (p. 219-220).

Ausubel (1970) presented a paper on organizers and science teaching and stated that deliberate manipulation of crucial cognitive structure variables is an effective method of teaching science (p. 5). Novak (1976) researched the learning process and effectiveness of teaching methods in the classroom, laboratory, and field. After examining a dozen theories on cognitive learning, Novak decided: "The reason why this author has become so strongly impressed with Ausubel's theory derives from the parsimonious way in which it accounts for most of the cognitive factors crucially important in school learning" (p. 502-503).

Novak (1977b), in recommending an alternative to Piagetian psychology for science and mathematics education, gave his support to Ausubel's theory of meaningful learning and advance organizers. He offered this reply: "In order to facilitate meaningful learning, Ausubel has proposed that new knowledge can be more easily linked to relevant concepts on cognitive structure by use of advance organizers" (p. 458).

Novak also sees Ausubel's theory as compatible with constructivist views in that knowledge is synthesized, modified and evolutionary in character. "As I see it, constructivist views are also highly compatible with and complementary to an Ausubelian psychology of learning" (Helm & Novak, 1983, p. 122).

David H. Jonassen (1982), a well known researcher on how written discourse can be most effectively presented said, "organizers are probably one of the oldest, yet under-utilized, mathemagenic supplement" (p. 132). The research literature and conjecture about the efficacy of advance organizers spans over thirty years. However, the effectiveness of advance organizers still remains unresolved. Fortunately though, there are many qualitative and quantitative studies available.

Ausubel (1960) tested to determine if using advance organizers would improve the learning and retention of unfamiliar but meaningful verbal material. He achieved favorable results with 110 senior undergraduate students. It was found when undergraduates were first exposed to organizers presenting relevant material and appropriately inclusive subsuming concepts, they were better able to learn and retain unfamiliar ideational material dealing with the metallurgy of carbon steel. An interesting highlight was that the pedagogic value of advance organizers depended in part upon how well organized the learning material itself is.

The effect of discriminability in meaningful verbal learning on learning and retention was tested by Ausubel and Fitzgerald (1961). Expository and comparative organizers were used to test the effect prior knowledge had on the learning and retention of Christianity and Buddhism doctrines. One hundred fifty undergraduate students participated and a positive relationship was found for the organizer group, that had learned previously related concepts on Christianity, which served as subsuming anchors for new material on Buddhism.

Ausubel and Fitzgerald (1962) conducted a study with one hundred forty-three senior undergraduate students at the University of Illinois. They were tested on learning and retention of two unfamiliar passages about endocrinology. The experimental group used an advance organizer; the control group did not. It was found that general background knowledge in endocrinology facilitated learning and retention in one of the two passages with learners who had low verbal and analytic ability.

Karahalios, Tonjes, & Towner (1979) in a study with 76 seventh grade students, conducted a one week unit on science text dealing with measurement of mass and length. It was found that using an advance organizer, that included the major concepts, made a significant difference in learning and retention, compared to students without one.

A number of other research studies (Ausubel,1963a; Ausubel and Youssef, 1963; Koran and Koran, 1973; Kuhn & Novak, 1971; West and Fensham, 1976; and Alexander, Frankiewicz, and Williams, 1979) have shown positive results and confirm that advance organizers enhance meaningful learning.

Several comprehensive reviews and meta-analysis noting the advantage of advance organizers were also conducted. Novak, Ring, & Tamir (1971) reviewed 156 studies, that dealt with important parameters in Ausubel's learning theory, in an attempt to determine their relevancy to several issues in science education. They concluded that Ausubel's learning theory (1963) as a theoretical base to underpin science education is "a promising base for future research formulation" (p. 484).

Kozlow (1978) in a meta-analysis of 77 studies, discovered most results supported the research in favor of advance organizers.
In another study Mayer (1979) examined 44 research studies on advance organizers and concluded the evidence clearly shows that they can have a positive effect on learning.

Luiten, Ames, and Ackerson (1980) in the most comprehensive review of advance organizer research, analyzed 135 studies and unequivocally supported the notion that advance organizers have a facilitative effect on both learning and retention (p. 217).

Also, a meta-analysis was conducted by Anderson et al (1982) on the use of advance organizers and science. The outcome supports the advance organizer as a viable and useful teaching strategy. (p. 350) This study represents 35% of the studies done on advance organizers from 1957 - 1980.

Stone (1983) analyzed 112 studies with Glass's meta-analysis technique and overall advance organizers were found to increase learning and retention. An interesting addition is that the science/math subject group showed the greatest significant results.

Newell (1984), in his review of the latest research on advance organizers, lends his support to a small but consistent facilitative effect upon learning (p.13).

The most recent review of research studies to validate advance organizers was done by Williams (1992). He points to the value of advance organizers and also highlighted a number of improvements that should be made.

Notwithstanding, results of a number of studies and meta-analyses have questioned advance organizers and their usefulness.

Anderson, Spiro, & Anderson (1978) in a study with 75 undergraduate students, tested to see if a prior passage on food-order information would act as an advance organizer for material to be presented later. In testing two groups, one with the prior passage and the other group without it, no significant difference was noted. This led them to conclude: "that the theoretical justification for the advance organizers is quite flimsy" (p. 439).

Barnes & Clawson (1975) analyzed 32 studies on advance organizers that had been carried out over fifteen years. They were examined to determine whether advance organizers facilitate learning. Their review looked at three areas. First, the studies were reviewed to determine if a significant difference was reached in favor of advance organizers. Of the thirty-two studies, twelve had a positive effect supporting advance organizers, twenty did not. Next they were examined according to selected variables such as length of the study, ability levels of the students, the content or subject matter being learned, and others. No clear patterns emerges to support the positive effect of advance organizers. Thus they concluded, "from this review that advance organizers, as presently constructed, generally do not facilitate learning" (Barnes and Clawson, 1975, p. 651). The last part of the study included nine recommendations for improvements that would help in the use of advance organizers.

Hartley and Davis (1976) reviewed the advance organizer research and put the studies into two broad groups: the initial studies and the later more sophisticated studies. They had reservations about the early studies because they involved, to a large extent, only college and university students and were conducted by Ausubel and a small group of his colleagues; in addition, none of the studies described the procedures for operationalizing advance organizers (p. 254). The later studies broadened the range of students and subjects used. However, the results were not so overwhelmingly in support of advance organizers; in addition, methodological flaws and inconsistencies still existed. One of their recommended improvements was that advance organizers other than prose, e.g. games, models, and visuals, be considered.

Clark and Bean (1982) found that after 20 years of research there is still little empirical evidence to support advance organizers. Two reasons why the research is responsible for this claim is the lack of advance organizer construction and definition, plus the lack of valid descriptions of learning outcomes.

The literature on advance organizers is voluminous; however, five common weaknesses appear from the various reviews and studies on advance organizers:

1. Barnes & Clawson (1975), plus Hartley & Davis (1976) find the most pervasive criticism of advance organizers is the lack of an adequate operational definition on how to construct the organizers.
2. Barron (1970) claimed students did not understand the intended use of the organizer.
3. Rickards (1976) found difficulty with prose organizers because they may be too difficult for a student to hold in memory when dealing with the text material.
4. A reason for the non-facilitating effects of organizers in many studies may be that organizers with single-theme passages are used, Rickards (1976) contends. In order to realize the full benefit of the subsumptive process multi-thematic material must be presented for assimilation into comprehension.
5. Barnes & Clawson (1975) also noted a shortcoming in organizer research because of testing procedures. They state that many investigators neglected to report quantitative statistics for the tests of their experiments.

Noel et al. (1980) alleviated some of the confusion about the role and purpose of advance organizers. They found a marked improvement in results if instructions explaining the organizers, and it's special functions, were added. This also attributed to the effectiveness of the advance organizer.

Those who question the effectiveness of advance organizers raise common concerns - the lack of an operational definition and instructions regarding the implementation of advance organizers. Williams and Butterfield (1992) in their recent review of research on advance organizers suggest that still the weakness of advance organizers lies in an inadequate operational definition and conflicting characterizations (p. 259).

Not all the criticism about the effectiveness of advance organizers has gone unanswered. Lawton & Wanska (1977) in their reply to the critical review given to advance organizers by Barnes & Clawson (1975) pointed out a number of inconsistencies and limitations in the ways the studies were reviewed and compared. They questioned Barnes and Clawson's selection of variables, the type of analysis they did, and their definition of a single study. Lawton and Wanska then went on to say, Barnes and Clawson's study, "serves primarily to point out the current confused picture of the status of advance organizers, resulting from the contradictory evidence of the cumulative investigations on this subject" (p. 236).

In defense of advance organizers Ausubel (1978) made a reply to the critics. The most common flaw targeted by researchers is that there is no clear definition of an advance organizer and how to construct one (Barnes and Clawson, 1975; Hartley and Davies, 1976). Ausubel's cites various studies (Ausubel, 1960; Ausubel & Fitzgerald, 1961, 1962;

Ausubel & Youssef, 1963) that meet this criteria and, as well, Ausubel (1963b, 1968) describes how to make an organizer for a particular topic. Also, Joyce & Weil (1972) operationalized organizers in relation to teaching concepts and facts in multiplication. Ausubel (1978) also pointed out that advance organizer results have shown a consistent 10% to 18% increase in mean learning score (p. 256).

Ausubel (1980) in his reply to Anderson, Spiro, & Anderson points out that they have not paid close attention to the research in the last 20 years, and close scrutiny of their "assertions indicates that they are completely unspecified, unsubstantiated, and undocumented, as well as based on indisputable misrepresentations of published material and on logical non sequiturs" (p. 400).

As a result of the common concern about the lack of an operational definition and instructions about advance organizers, many researchers have added their refinements to better operationalize their organizers. This emergent trend was explicitly noted by Hall (1977). "The nebulosity of Ausubel's guidelines for making organizers has led to their lack of uniformity in construction: the work of several researchers lend support to Ausubel's theories of the advance organizer" (p. 11).

VISUAL / GRAPHIC ORGANIZERS - METACOGNITIVE HEURISTICS

Over time research on advance organizers has noticed emerging trends to address concerns about Ausubel's learning theory and the advance organizer. Weisberg (1970) in a study with ninety-six eight-grade students on learning earth science concepts noted a trend in research that favors presentation of data that is visual instead of verbal (p. 161). After adapting Ausubel's advance organizer, Weisberg received favorable results for the use of "visual" organizers. He contrasted a graph and a map-type advance organizer to a verbal form. He stated: "The results raise serious questions as to the value and use of verbal organizers; especially when other, more fruitful materials are available to us in the classroom and as supplementary materials in textbooks" (p. 164).

Most of the advance organizers were in prose form, according to Barnes and Clawson (1975), who studied the efficacy of 32 studies. It was their recommendation that studies using a wide variety of nonwritten advance organizers constructed according to the general criteria espoused by Ausubel be conducted (p. 656).

Jonassen (1982) noted that effective organizers were not always in prose form and that Ausubel, on different occasions, has advocated the use of concrete models or diagrams as organizers. Anderson et al. (1982), in a meta-analysis study on advance organizers and science, suggested that future studies should use different variations of advance organizers (p.369).

In a meta-analysis of advance organizer studies Stone (1983) found that there was a higher effect size when the advance organizers were nonwritten or illustrated especially in science and math at the junior high and preschool level.

Searls (1983), in her review of advance organizer studies, noticed that Ausubel did not specify the format for an advance organizer. He used prose passages which students read before reading the new material. In recent analysis of advance organizer studies, Luiten, Ames, and Ackerson (1980) have reported a number of other types of presentation modes (p. 245). Searls (1980) also noted that any introductory activity which adheres to Ausubel's principles or guidelines for the construction of an advance organizer would suffice and be successful in enhancing meaningful learning.

Alexander et al. (1979) in a study with 270 fifth-, sixth-, and seventh-grade students extended support for Ausubel's hypothesis beyond the limits of written advance organizers. It was reported that visual advance organizers (slide presentation) and verbal advance organizers (oral presentation and discussion) had a significant effect on learning and retention in social studies.

Another emergent form of the prose advance organizer proposed by David Ausubel (1963) had surfaced. Tajika, Taniguchi, Yamamoto, and Mayer (1988) had success with pictorial advance organizers with 12 grade five students. In this case the pictorial advance organizers were concrete pictures such as a drawing or a photograph.

Platten (1991) in a paper on teaching concepts and skills of thinking simultaneously, stated: "more recently, researchers have turned their attention to an 'off-shoot' of the advance organizer, or more simply, the graphic organizer" (p.9).

Barron (1970), and Hawk (1986) have pioneered graphic organizers successfully. One variation of the typical prose advance organizer was noted when, Barron (1970), conducted a study on reception learning and retention of general science content with grades six through twelve. He constructed graphic (visual) advance organizers, or more simply, the graphic organizer. They were defined as "visual and verbal presentations of the key vocabulary in a new learning task" (p. 3) . In doing this he wanted to overcome one of the major criticisms with Ausubel's advance organizers - a poorly operationally defined pedagogical tool (Barnes & Clawson, 1975). Also, in dealing with another weakness stated in advance organizer, Barron included time for explaining the use of the organizer to the students. In a later study Barron (1980) based his graphic organizer upon the same theoretical rationale as Ausubel's prose organizers and declared the graphic organizer may be regarded as a special form of advance organizer (p. 3). Barron (1970) had this to say about graphic organizers:

> In contrast to prose organizers, graphic organizers appeared to hold a number of advantages. First, unlike prose organizers, graphic organizers have been operationally defined. It has been ascertained that they can be constructed and used by combining a minimum of training with a relatively simple set of directions. Second, whereas prose organizers are designed to be read by the learners, graphic organizers call for an interaction between teacher and students. Thus, when using the latter device, a teacher is able to evaluate its appropriateness in relation to the learner's existing background of knowledge (p.3).

Closely related to the concept of advance organizer is the graphic organizer developed by Hanf (1971) that arranges information in hierarchical order while keeping words to a minimum. "The effect is that of perceptual comprehension rather than verbal. Instead of reading the information, one sees it. The gestalt, seeing the whole and all its related parts, yields a powerful impact, immediate comprehension and easy retention" (p. 226).

Stewart (1989) noticing this emerging heuristic stated: "What constitutes a graphic advance organizer is really any appropriate mixture of verbal and graphic material which related to the structure of text" (p. 5).

Moore & Readence (1984) in a quantitative and qualitative review of graphic organizer research stated that graphic organizers developed by Barron (1970) were a variation of Ausubel's advance organizer. In the meta-analysis of 23 studies it was found that graphic organizers increased learning. Another interesting finding was that graphic organizer treatments affected vocabulary knowledge more than overall comprehension. This seems a likely explanation considering graphic organizers are skeletal arrangements made up mostly of terms. It was also noted that a worthwhile extension of the research would be to compare graphic organizer effects on comprehension and vocabulary with flow-charting and mapping effects. Also, the subjective reports of teachers' perceptions of preparedness suggested that graphic organizers seem to help teachers clarify their instructional goals by providing a schema of the upcoming material to be taught.

A number of empirical studies have been conducted on graphic organizers and their effectiveness as a metacognitive heuristics. Vick & Lynn (1983), contrasting prose organizers with graphic organizers, found that the latter appears to hold a number of advantages (p. 9).

Hall (1977) also had positive effects using graphic advance organizers with ninth-grade students of below-average reading ability.

The results support the use of nonprose advance organizers as another possible instrument for learning and retention (p. 10).

Hawk (1986) conducted a study on graphic organizers and life sciences with six-grade and seven-grade students. Results indicate that using graphic advance organizers is significantly beneficial to student achievement (p. 81).

The graphic organizer itself has undergone several modifications. Alverman (1981) constructed graphic organizers using lines, arrows, and hierarchical ordering of ideas to represent a text's organizational structure (p. 44).

A debate which has arisen in the area of graphic organizer studies is as to the position of the organizer within the lesson or presentation. Dean and Kulhavy (1981); Dean and Enemoh (1983) found that comprehension and remembering of prose material was facilitated when their graphic organizer was presented prior to the material to be studied. Alverman (1981); Alverman and Boothby (1982, 1986); plus Mayer and Bromage (1980) noted the positive effects of using organizers during the lesson.

Another technique is to use organizers after the material in a lesson has been taught. Barron (1980); Barron and Stone (1974); Bertou, Classen, and Lambert (1972); Horton and Lovitt (1989); and Horton, Lovitt, and Bergerud (1990) recommended the application of organizers at the end of the lesson. Other studies have found favorable results when organizers were used during and after the lesson. Tajika et al. (1988) found that recall of information could be improved by using an integrated organizer both during and after the reading of material.

Dana (1980) tested the effects of a graphic organizer used before, during, and after reading on the comprehension and retention of written text with sixth-grade students. The results supported the use of the organizer in all three positions on comprehension and retention of multithematic text. This study followed Dana in using the organizer before, during, and after the lesson taught.

CONCEPT MAPS

The desire to improve achievement through meaningful learning led to research into effective metacognitive heuristics that emphasized the importance of learner-centeredness in the teaching / learning process. One such heuristic that evolved is the concept map.

Malone & Dekkers (1984) thought of concept maps in this way: "Concept maps have been called 'windows to the mind' of the students we teach: for seeing in (by the teacher and other students), for seeing out (by the student) and for reflecting on one's perceptions (by everybody)" (p. 231).

Throughout the years concept maps have been used for many purposes. Stewart, Van Kirk, and Rowell (1979) have used them for instructional devices; Novak (1981), Ross and Munby (1991) as evaluation tools; Ault (1985) for lecture preparation and laboratory reports; and Cliburn (1986) has used them to develop curriculum.

Joseph Cliburn (1986) who has had extensive experience with operationalizing concept mapping in biology gave this advice on how to go about creating a map. The very inclusive generalization is placed above the subordinate ideas. In doing so the concepts are listed vertically according to their level of generality within the particular conceptual system. Propositional relationships - statements that link concepts - are indicated by labeled linking lines (p. 377).

Concept maps were also developed by Moreira (1979) in physics, and Stewart et al. (1979), Cliburn (1987), plus Roth and Bowen (1993) for use in biology teaching.

Joseph Novak, Cornell University, has been studying the phenomenon of human learning for over two decades. After researching, studying, and testing Ausubel's learning theory for fifteen years, Novak combined Ausubel's work on meaningful learning with his own interests in the central role that concepts play in science. Ausubel's influence was noted by Novak:

> Published in six languages, Ausubel's theory has had world-wide recognition, but probably least acceptance in the U.S.A. Nevertheless, our research group continues to find his theory, with a primary emphasis on the nature of meaningful learning, the most powerful and comprehensive for our work. We have added some aspects of "cognitive science" to the theory and further modified the theory as regards cognitive development (Helm and Novak, 1983, p. 118).

From 1974-1976 Novak, with the help of Rowell, developed an evaluation strategy called "concept mapping." Novak's (1976) concept mapping heuristic is an extension of Ausubel's influence. "Ausubel's cognitive learning theory provides a sound intellectual foundation for creating new teaching and learning events in classrooms that can lead us to improved educational practices over the next few years" (p. 12).

Helm and Novak (1983) originally used concept maps to analyze interview data and then found its usefulness as a direct instructional technique. Over time Novak & Gowin (1984) operationalized the concept map and its various pedagogical applications in the book *Learning how to Learn.*

Joseph Novak, (Helm and Novak, 1983), at the address to open the International Conference Misconceptions in Science and Mathematics at Cornell University, stressed the importance of concept maps as a pedagogical innovation:

> First, until the 1960's, we did not have an adequate theory of learning that could guide educational practice in classrooms and that addressed

> the key issues of cognitive development. We believe that Ausubel's assimilation theory of cognitive learning, combined with new instructional strategies based on this theory (Novak and Gowin 1984), can be a psychological foundation for qualitatively improved instruction. Second, advances in epistemology (or our understanding of the nature of knowledge and knowledge production) are highly complementary to the latter psychology of learning in that both stress the evolutionary (or ontogenic) development of hierarchically organized conceptual frameworks. Third, we believe that the development of pedagogical and instructional strategies such as "concept mapping" and "vee mapping" provide a means to help students "learn how to learn" and to understand the nature of knowledge production. We believe these two instructional strategies are only the first of a potentially significant number of new pedagogical innovations that are "theory driven" (Helm & Novak, 1983 p. 14).

According to Novak (1984) a concept map is a visual heuristic used to represent a conceptual system. It represents the hierarchical ordering of concepts according to their level of generality and specificity.

Novak's approach is consistent with Ausubel's (1963) meaningful learning which is promoted by the understanding of the hierarchical relationships and linkages between concepts. This is the main target of the concept map heuristic in which students are taught to identify the network of relationships between concepts rather than discrete isolated entities favoring rote learning.

Novak (1980b), in his research on progress in application of learning theory in science teaching, based his concept mapping strategy on Ausubel's key concepts of assimilation theory for cognitive learning. "Learning becomes more meaningful, when instruction is planned to encourage subsumption, integrative reconciliation, superordinate learning and progressive differentation and utilized advance organizers" (p. 61).

Novak (1981) describes adapting concept mapping for the teaching of biology as: "a process that involves the identification of concepts in a body of study materials and the organization of those concepts into a hierarchical arrangement from the most general, most inclusive concept to the least general, most specific concept" (p. 3).

Novak (1981) later went one step further and extended the work by Moreira on concept maps by adding proposition words or "labels on the lines" to semantically link or show relationships between two or more concepts. The propositions, along with the levels of hierarchy, facilitated what Ausubel calls progressive differentation of the concepts. Then further refinements led to cross links between concepts by Novak (1984). These linked concepts once assimilated are "good indicators of integrative reconciliation of meanings" (p. 611).

Novak (1984) in his research over the years has refined concept mapping:

> Because meaningful learning proceeds most easily when new concepts or concept meanings are subsumed under broader, more inclusive concepts, concept maps should be hierarchical; that is, the more general, more inclusive concepts should be at the top of the map, with progressively more specific, less inclusive concepts arranged below them (p. 15-16).

Several empirical studies on concept mapping have been published. Armbruster and Anderson (1980) indicated positive results were found with 11 grade eight students using mapping as a reading comprehension strategy. They found concept mapping helped in processing text in a way that facilitated recall and is an important study strategy.

Stice & Alvarez (1986) conducted a study which introduced concept mapping to kindergarten through fourth grade students. Their findings indicated the value of concept maps as viable heuristics for young learners (p. 8). It was also reported that concept maps also helped the teachers in organizing and presenting the material to be learned.

Pankratius (1990) found favorable results with concept maps presented prior to instruction in six high school physics classes. The treatment group that mapped concepts prior to instruction had posttest scores 18.4% higher than the control group.

Schmid and Telaro (1990) used concept mapping for biology instruction in a Montreal high school. Students were put into one of two instructional strategies. One group used the traditional textbook approach, while the treatment group used the concept mapping strategy in learning biology over a four-week session. "The results of this study reflect positively on the implementation of concept mapping in high school biology, and the general findings offer support for the use of concept mapping" (p. 82).

In a study to test the usefulness of concept maps as a learning tool McCagg and Dansereau (1991) tested 81 undergraduate students enrolled in a psychology course at Texas Christian University. Throughout the course the treatment group received instructions and practice on concept mapping. At the end of the course two 30-item multiple choice tests were administered. The results proved concept mapping to be a learning strategy that positively affected students' performance on recognition and recall tests.

Novak (personal communication, November, 1993) said science is ideally suited to mapping as it can be dealt with on a conceptual level. The results of several research studies into the use of the concept mapping heuristic reveal that meaningful learning is achieved through its use in science classrooms (Ault, 1985; Cliburn Jr., 1985a; Moreira, 1979; Novak, 1979; Jegede and Okebukola, 1989; Malone and Dekkers 1984; Novak et al, 1983; and Stewart et al, 1979.

Not all studies in science have revealed the positive results. Gurley (1982) conducted a nine-month study in science with eighty-five grade nine and eleven students at a suburban high school in Illinois. The treatment group used concept maps and the control group used the traditional textbook method of instruction. Gurley's guiding principles for the research were those provided by Ausubel's (1968) assimilation theory of meaningful learning and Novak's (1977) theory of education. Throughout the study several observations were noted: Concept mapping seemed to improve over time, but a "burn out" effect for making concept maps was admitted by some students during interviews with the researcher. Although the treatment group did not reach a significant difference Gurley (personal communication, November 1993) has since refined her concept mapping process to prevent the "burn out" effect. She uses a self-designed software tutorial program and handouts on concept mapping.

Novak, Gowin, & Johansen (1983) used concept maps with grade seven and eight junior high school science students. Higher ability students tended to do better, and good to poor concept maps were achieved by students in all four ability groups. Although no significant differences were achieved on their first comprehensive study on concept maps, the results point to the value of concept maps as a curriculum, instructional, and evaluation tool.

In another study, Sherris & Kahle (1984) did not reach significant differences on posttest scores after a five-week unit comparing 282 high school biology students using concept maps with 259 students not using concept maps. Heinz-Fry & Novak (1990) tested the usefulness of concept mapping for a college autotutorial biology class. No significant difference between the control and treatment groups were found (p. 468).

Lehman, Carter, & Kahle (1985) did a study involving 243 inner-city black students. After an eight-week biology unit there was no significant achievement difference between the 119 students using concept maps and 124 students using text outlining. Also, Pankratius & Keith (1987) in a study with 103 grade nine general science students over an 18 week period found no difference in concept mapping when compared to text outlining.

Stensvold and Wilson (1990) used concept maps for six chemistry laboratories relating to reactions of chemical compounds with 104 ninth-grade students over a week. The results did not reach levels of significance between the treatment groups on the 33-item comprehension test but, qualitatively, the usefulness of concept mapping was observed.

There are always conflicting studies regarding any issue; however, after examining the data on concept mapping Novak (1990), in a report on the research to date on concept maps involving students from grade one to university instruction, concluded that the data from a variety of qualitative and quantitative research studies strongly support the use of concept maps.

In a twelve-year longitudinal study of science concept learning Novak & Musonda (1991) provided audio-tutorial science lessons to 191 first and second grade students. "The remarkable finding of this study is that a relatively few hours of high quality science instruction in grades one and two apparently served as a kind of advance organizer for many students for later instruction in science" (p. 147-148). The results point to the impact of concept maps as a representational tool for cognitive development changes.

Roth (personal communication, January, 1994) also found several social benefits associated with concept mapping. He finds the students more cooperative, attentive, and has noticed an increase in motivation.

CONCEPT MAPS AS ADVANCE ORGANIZERS

Concept maps have been used for three reasons: as an instructional tool to sequence material, for a curriculum tool to emphasize major concepts and their relationships, or to evaluate the understanding or misconceptions that exist in a students mind (Ault, 1985, p. 42).

Recent research has extended the work by Ausubel and Novak to include the concept map as a preinstructional device, a concept map as an advance organizer. According to Novak & Gowin (1984), meaningful use of concept maps as an advance organizer can best be achieved by (1) picking out the key concepts, (2) establishing the students relevant concepts existing in their cognitive structure, (3) helping the students link the relevant concepts and how they fit into the hierarchy, and (4) helping them discriminate between the more inclusive concepts.

This approach is consistent with a cognitive constructivist learning approach as this technique is an interactive process between the student and the material.

It was found, in a study on concept mapping with young children, that teachers with more background in a topic constructed more explicit maps as compared with students. As a result a concept map presented as an advance organizer would be more complete, accurate, and detailed as a preinstruction strategy (Stice & Alvarez, 1986).

Cliburn (1990) noted the value of using the concept map as a curricular and instructional tool. He found this strategy different from the student prepared concept map in that this method was chiefly expository in nature. He related to teaching in this fashion:

> My work with teacher-prepared maps in the classroom over the past seven years has convinced me that, when thoughtfully applied in a systematic fashion, this strategy facilitated both content-specific learning by students, and has other advantages as well (p. 212).

The decision to use teacher-generated concept maps, as opposed to student-generated maps, according to Cliburn (1990) "strongly confirms the effectiveness of concept map advance organizer systems for promoting long-term retention" (p. 217). Cliburn (personal communication, October, 1993) emphasized the expository component of the teaching-learning transaction in that the teacher is crucial in presenting the material as well as guiding the students through the conceptual development of the science material. Prior organization and sequencing of conceptual lessons following the concept map is of utmost importance he found.

As well, Novak (1977b) has found that constructing valid student-generated concept maps is very difficult for students with limited prior knowledge about a topic. Novak also found that concept mapping can be time consuming and is a process that takes valuable class time.

Cliburn (1985a), using an Ausubelian approach to instruction, conducted a study comparing two systems for organizing and presenting science material. He used concept maps as advance organizers to organize and present a three-week unit of a junior college anatomy and physiology course to 82 students. This method was contrasted with the traditional textbook approach. A thirty-item multiple-choice immediate posttest determined a positive difference in learning for the treatment group. However, a significant facilitating effect on retention was achieved by a delayed posttest. From this study Cliburn concluded that using concept maps as advance organizers had a positive effect on learning while significant results were achieved for the treatment group on a content-specific delayed posttest. Cliburn (1985b) also confirmed in a subsequent report that using concept maps as advance organizers is a valid tactic for reducing rote learning.

In another similar study Roth (1990) used concept maps as advance organizers in a rural junior high school in Canada for science instruction. In a lab dealing with physical and chemical changes, Roth found this advantage of using a concept map as an advance organizer:

> It is critical to introduce the concepts of chemical and physical changes (such as color, shape, and phase) that students will see during lab. The concept map makes the evidence for each type of change explicit. The map shows which concepts the students should understand before progressing to more difficult subjects (p. 31).

Roth found by using the concept map as an advance organizer to plan a unit he was able to achieve more clarity and was able to plan the flow of the entire unit better. Some qualitative benefits observed were that students indicated they learned to think more clearly, read material more effectively, and acquire a great deal of knowledge about the subject.

> My students like me to use teacher-prepared concept maps as advance organizers (placing individual lessons in a coherent whole). Instead of just learning sequential ordered material, my students can see the whole picture. This leads to a more integrated knowledge base. I also noticed increased enthusiasm, eagerness for lab work and independent learning, and greater classroom productivity. They will get your students actively involved in scientific inquiry, putting them in the focus. You can watch your students develop into more responsible, active, and thinking adolescents who want to come to science class. Your students

> will be a breath of fresh air in comparison to the large numbers of passive students who attend classes "to get it over with" (p. 34).

Willerman & Mac Harg (1991) in a study using a concept map as an advance organizer found that: "concept mapping is probably more informative, accurate and complete for students if the teacher presents to them a concept map he prepared at the start of the unit" (p. 706). The study involved 90 grade eight students in four physical science classes at a middle school in a north Chicago suburb, students were given a two-week unit dealing with the physical and chemical properties of elements and compounds. "The results indicated that concept maps used an advance organizer can significantly improve eight-grade science achievement" (p. 709).

Roth and Yore (1992) also have found advantages with students from grades seven through nine over the past six years with using concept maps for a variety of modes including a preinstructional heuristic. They found this strategy to "lead not only to a higher level of learning but also to positive attitudes toward science" (p. 17). It was also pointed out that future advancements with applications of organizers to guide and facilitate science learning could be enhanced with use of the computer applications.

RATIONALE

Education theorists David Ausubel (1963, 1968) provides the theoretical framework and Joseph Novak (1985) provides the teaching application upon which this study is based. To these constructivists, meaningful learning is a change in one's cognitive structure in which new information is linked to prior knowledge. Ausubel contended that learning occurs only when the new information is sufficiently meaningful to be relevant to what the learner already knows or wants to know (Prather, 1990, p. 8).

Learning can be facilitated by the advance instruction of relevant subsuming concepts which Ausubel (1963) calls organizers and using the concept mapping technique developed by Joseph Novak (1976, 1984). This hypothesis was based on the assumption that the cognitive structure is hierarchically organized in terms of highly inclusive concepts under which are gathered less inclusive sub concepts and information. Thus, if these subsumers are available in the cognitive structure, they should facilitate meaningful learning of material.

The purpose of this study was to test the hypothesis that the learning of unfamiliar, but meaningful, material can be facilitated by using concept maps as advance organizers. The specific research question is: Do concept maps as advance organizers help in the learning of grade seven science material?

CHAPTER 2
METHOD AND PROCEDURE

SUBJECTS

This study involved a population of grade seven science students at A. J. Smeltzer Junior High School, Lower Sackville, Nova Scotia, Canada. The socioeconomic status of this school's attendance area included blue collar workers to professionals. Lower Sackville is located twenty kilometers from Halifax, the capital city of the province of Nova Scotia. Lower Sackville has a population of 35 000 people.

Eighty-nine students in four classes were involved in the study and were taught by the researcher. Immediately before the start of the experiment the four participating classes wrote a pretest to determine if there was any significant difference between the classes. They were then assigned to an experimental and control group. Again the students pretest scores were tested to determine if there was any significant difference between the experimental ($\underline{N}$ = 44) and control ($\underline{N}$ = 45) groups. There was no significant difference between the four classes or the experimental and control groups. See Tables 1 and 2 in the results section. After the conclusion of the Living Things unit the control and experimental groups were reversed for the next unit on Solutions. The students wrote another pretest to see if there was any significant difference between the four classes. Again the students pretest scores were tested to determine if there was any significant difference between the experimental ($\underline{N}$ = 45) and control ($\underline{N}$ = 44) groups. No significant difference was noted. See Tables 4 and 5 in the results section.

MATERIALS

The resource material used for this experiment with all four classes was based on the SciencePlus 1 textbook and Teacher's Resource Book, (Atlantic Science Curriculum Project, 1986).

The materials used for the control group followed the traditional prescribed textbook and materials approach for teaching the two science units - Living Things and Solutions. To do this the teacher followed the sequence and content outline of the unit as presented i.. the SciencePlus 1 text and the Teacher's Resource Book.

The experimental group used the same materials and content as the control group. However, the teaching/learning heuristic was different in that concept maps as advance organizers were used to sequence and present the science content to help students assimilate new knowledge and achieve meaningful learning.

The concept maps as advance organizers used with the treatment groups were written by the researcher following the guidelines of Ausubel's advance organizers (1968) and Novak's concept maps (1984). The procedure to operationalize the concept maps as an advance organizers for the Living Things and Solutions units followed the steps recommended by Zeitoun (1983) on advance organizers and Pankratius and Keith (1987) on concept mapping. The following steps were followed:

1. The primary sources of material were obtained.
2. The key concepts, facts, and events relating to the unit were identified.

3. These were reconstructed in a way in which the significance of meaningful learning (Ausubel 1968, Novak !984) would be obvious and facilitated.

The following guidelines were followed in operationalizing concept maps as advance organizers for the living things and solutions units for the experimental groups:

1. Analyze the learning materials and content.
2. Pick the main concept, then the other key concepts. Rank them from the most inclusive to the most specific. Then group the concepts according to level of abstraction and relatedness. Following that arrange the concepts in a two dimensional array, then link the related concepts and label each link. Finally, look for cross links.
3. Check the readability and understandability of the maps.
4. Revise.
5. Put the concept map as an advance organizer on a regular sheet of 8 1/2 by 11 sheet of paper.
6. Make teacher's copy and students' copies, then make a copy for the overhead projector. See appendix A for Living Things Maps and appendix B for the Solutions Maps.

The structure of the concept map for the Living Things unit had 36 concepts, 7 levels of hierarchy, 2 main branches, and 1 cross link. See Appendix A, Figure 1 for the Teacher Concept Map-Living Things Unit and Appendix A, Figure 2 for the Student Concept Map - Living Things Unit.

The structure of the concept map for the Solutions unit had 35 concepts, 10 levels of hierarchy, 2 main branches, and 2 cross links. For the Teacher Concept Map-Solutions Unit see Appendix B, Figure 3. For the Student Concept Map - Solutions Unit see Appendix B, Figure 4.

The instrument chosen to measure learning of science for each unit under study consisted of an Anova of the pretest and posttest scores. See Table 3 and 6 in the results section. At the conclusion of the twelve-week experiment attrition accounted for the absence of two students from the results of the solutions posttest.

The pretests and posttests were comprised of twenty multiple-choice questions selected from a pool of teacher prepared questions. Test questions covered all levels of Bloom's (1956) cognitive taxonomy. The control and experimental groups were not notified or encouraged to study for the pretest and posttest and since it was intended as a power test no time limit was imposed.

PROCEDURE

This study utilized two conceptual topics in grade seven science, Living Things and Solutions, in the SciencePlus 1 text and the Teacher's Resource Book. The content, resource materials, and lesson objectives for each unit came from these two primary sources. Classes were 43 minutes in duration and each unit lasted 6 weeks.

Before conducting the experiment, the instructor prepared materials for the treatment groups. Lesson plans were outlined and sequenced according to the treatments. Both groups followed the lessons that were outlined in the textbook SciencePlus 1 and the Teacher's Resource Book.

During the experiment the two classes in the control group received instructions in accordance with the objectives, outline and sequence prescribed by the SciencePlus text and the Teacher's Resource Book. At the start of the unit, and prior to the daily lessons, the teacher-constructed advance organizer concept map was presented to the experimental group on the overhead projector.

According to Ausubel, Novak, and Hanesian (1978) the advantage of deliberately constructing an advance organizer for the unit material is that only in this way can the learner enjoy the advantage of subsumption. This gives the student a general overview of the more detailed material in advance of actual being confrontation with it, and also pervades organizing elements that are inclusive of and take into account the particular content contained in the material (p. 172).

Students also received a blank concept map with spaces arranged in hierarchical fashion. See Student Concept Map-Living Things Unit, Appendix A, Figure 2 and for the Student Concept Map-Solutions Unit see Appendix B, Figure 4. The student maps did not contain any concepts, propositions, or linking words.

At the beginning of each class the instructor explained the relationship between each concept and identified their linkage. The concept map was explained in the context of an advance organizer so the students could recognize the relationship between the main and subsuming concepts. The students then completed their maps by putting in the concepts, proposition lines, and linking words. They were also told that they could modify their maps at any time. This method of completing the concept map was utilized because, as Pines and West (1986) said: "According to the constructivist, learning and the growth of understanding always involves a learner constructing his or her own private understanding of some part of the public knowledge" (p. 584). The student maps were checked for completeness and accuracy. This advance organizer concept mapping procedure took about four to five minutes at the beginning of each class. The days lesson then related and referred to the concepts and linkage of what was just discussed.

The educational content and material was identical for both the control and experimental groups. The instructor presented the content in the normal fashion. They included hands on activities, experiments, reading assignments, questions, word problems, simulations, teacher presentations, whole group and small group discussions, and homework. The only thing that was different was the preinstructional strategy used by the experimental group

To ensure comparability between the two groups, time spend on concept maps by the experimental group was matched with the control group by spending the same amount of time on examples in the lowest level of the hierarchy.

After the six-week unit on Living Things was completed, a posttest to determine learning was administered to both groups. Following that the control and experimental groups were reversed for the next unit on Solutions and the same procedure was repeated for the next six weeks.

Because in this study the experimenter and the researcher were the same, there is the possibility that the results may be partially or wholly due to an experimenter expectancy effect (Rosenthal, 1976). While this should be kept in mind when interpreting the results, it characterizes most teacher conducted classroom research and is not unique to this study.

CHAPTER 3
RESULTS

PRETEST FOR CLASS COMPARISON - LIVING THINGS

Prior to the start of the experiment, to test for homogeneity of variance between the four participating classes, an F-test was conducted using pretest scores on Living Things. See Table 1.

The F-test analysis indicated no significant difference ($F = 0.118$, $p > .05$) between the four participating classes.

TABLE 1

Pretest for Class Comparison - LIVING THINGS

One Factor ANOVA X 1 : Class Y 1 : Pretest Living

Analysis of Variance Table

Source	Df	Sum Squares:	Mean Square:	F-test:
Between groups	3	2.875	.958	.118
Within groups	85	689.372	8.11	p = .9492
Total	88	692.247		

Model II estimate of between component variance = -.322

One Factor ANOVA X 1 : Class Y 1 : Pretest Living

Group	Count	Mean:	Std. Dev.:	Std. Error:
A 7D	21	11.429	3.37	.735
B 7F	23	11.391	2.919	.609
C 7O	22	11.818	2.839	.605
D 7S	23	11.391	2.19	.457

One Factor ANOVA X 1 : Class Y 1 : Pretest Living

Comparison	Mean Diff.:	Fisher PLSD:	Scheffe F-test:	Dunnett t:
A 7D vs. B 7F	.037	1.709	.001	.043
A 7D vs. C 7O	-.39	1.727	.067	.449
A 7D vs. D 7S	.037	1.709	.001	.043
B 7F vs. C 7O	-.427	1.689	.084	.503
B 7F vs. D 7S	0	1.67	0	0

One Factor ANOVA X 1 : Class Y 1 : Pretest Living

Comparison	Mean Diff.	Fisher PLSD	Scheffe F-test	Dunnett t
C-70 vs. D-75	.427	1 889	084	503

PRETEST OF CONTROL AND EXPERIMENTAL GROUPS

Prior to the start of the experiment, to test for homogeneity of variance between the assigned control (N = 45) and experimental groups (N = 44), an F-test was conducted using pretest scores on Living Things. See Table 2.

The F-test analysis indicated no significant difference ($F = 0.102$, $p > .05$) between the control and experimental groups.

TABLE 2

Pretest of Control and Experimental Groups

One Factor ANOVA X 1 : Group Type-L Y 1 : Pretest Living

Analysis of Variance Table

Source	DF	Sum Squares:	Mean Square:	F-test:
Between groups	1	.811	.811	.102
Within groups	87	691.436	7.948	p = .7502
Total	88	692.247		

Model II estimate of between component variance = -.16

One Factor ANOVA X 1 : Group Type-L Y 1 : Pretest Living

Group	Count	Mean	Std. Dev.:	Std. Error:
Control	45	11.6	2.508	.374
Experimental	44	11.409	3.105	.468

One Factor ANOVA X 1 : Group Type-L Y 1 : Pretest Living

Comparison	Mean Diff.	Fisher PLSD	Scheffe F-test	Dunnett t:
Control vs. Experimental	.191	1.188	.102	.319

LIVING THINGS PRETEST - POSTTEST SCORES

For the first unit in the experiment on Living Things, a 2-factor repeated measures ANOVA was performed. Table 3 shows the results and the means for the experimental (concept map as advance organizer) and control groups (traditional textbook approach).

While both groups showed a significant increase (pretest - posttest = 2.741, $p = .001$, $F_{AB} = 5.663$ $p = .0195$), the experimental group gained significantly more than the control group (average gain 3.509 vs. 2.000, $p = .0195$).

TABLE 3

Living Things Pretest - Posttest Scores

Anova table for a 2-factor repeated measures Anova.

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Group Type-L (A)	1	13.908	13.908	1.213	.2737
subjects w. groups	87	997.373	11.464		
Repeated Measure (B)	1	334.472	334.472	75.68	.0001
AB	1	25.028	25.028	5.663	.0195
B x subjects w. groups	87	384.5	4.42		

There were no missing cells found.

The AB Incidence table

Group Tx	Repeated Mea...	Pretest L...	Posttest ...	Totals:
Group Tx	Control	45 11.6	45 13.6	90 12.6
Group Tx	Experimen...	44 11.409	44 14.909	88 13.159
	Totals	89 11.506	89 14.247	178 12.876

PRETEST FOR CLASS COMPARISON - SOLUTIONS UNIT

Before the start of the second unit, an F-test was conducted using pretest scores on Solutions to verify whether any significant difference existed between the four participating classes. See Table 4

The F-test analysis indicated no significant difference ($F = 0.168$, $p > .05$) between the four participating classes.

TABLE 4

Pretest for Class Comparison - Solutions Unit

One Factor ANOVA X 1 : Class Y 1 : Pretest Solutions

Analysis of Variance Table

Source:	DF:	Sum Squares:	Mean Square:	F-test:
Between groups	3	3.618	1.206	.168
Within groups	85	609.663	7.173	p = .9178
Total	88	613.281		

Model II estimate of between component variance = -.268

One Factor ANOVA X 1 : Class Y 1 : Pretest Solutions

Group	Count	Mean:	Std. Dev.:	Std. Error:
A 7D	21	7.571	3.37	.735
B 7F	23	8.13	2.581	.538
C 7O	22	7.955	2.627	.56
D 7S	23	7.957	2.033	.424

One Factor ANOVA X 1 : Class Y 1 : Pretest Solutions

Comparison	Mean Diff	Fisher PLSD	Scheffe F-test:	Dunnett t:
A 7D vs. B 7F	-.559	1.607	.159	.692
A 7D vs. C 7O	-.383	1.625	.073	.469
A 7D vs. D 7S	-.385	1.607	.076	.476
B 7F vs. C 7O	.176	1.589	.016	.22
B 7F vs. D 7S	.174	1.57	.016	.22

One Factor ANOVA X 1 : Class Y 1 : Pretest Solutions

Comparison	Mean Diff	Fisher PLSD	Scheffe F-test	Dunnett t
C-70 vs. D-7S	.002	1.588	2.041E-6	.002

PRETEST OF CONTROL AND EXPERIMENTAL GROUPS

Preceding the next unit, on Solutions, the experimental ($\underline{N}$ = 45) and control ($\underline{N}$ = 44) groups were reversed then given a new pretest to determine if any between group difference existed. An F-test was conducted using pretest scores on Solutions. See Table 5.

The F-test analysis indicated no significant difference ($\underline{F}$ = 0.027, $\underline{p} > .05$) between the control and experimental groups.

TABLE 5

Pretest of Control and Experimental Groups

One Factor ANOVA X 1 : Group Type-S Y 1 : Pretest Solutions

Analysis of Variance Table

Source:	DF:	Sum Squares:	Mean Square:	F-test:
Between groups	1	.188	.188	.027
Within groups	87	613.093	7.047	p = .8706
Total	88	613.281		

Model II estimate of between component variance = -.154

One Factor ANOVA X 1 : Group Type-S Y 1 : Pretest Solutions

Group	Count	Mean	Std. Dev.:	Std. Error:
Control	44	7.864	2.962	.446
Experimental	45	7.956	2.316	.345

One Factor ANOVA X 1 : Group Type-S Y 1 : Pretest Solutions

Comparison	Mean Diff.	Fisher PLSD	Scheffe F-test:	Dunnett t:
Control vs. Experimental	-.092	1.119	.027	.163

SOLUTIONS PRETEST - POSTTEST SCORES

A 2-factor repeated measures ANOVA was performed to determine if a pretest-posttest effect was present. Table 6 shows the results and the means for the experimental and control groups.

While both groups showed a significant increase (pretest - posttest = 3.494, $p = .0001$, $F_{AB} = 6.437$, $p = .013$), again the experimental group (the former control group) outperformed the control group (the former experimental group), showing average score increases of 2.675 compared to 4.295, $p = .013$ .pretest-posttest scores for the control group ($N = 43$) were 9.174. Two posttest scores were missing as the students did not attend school for the later portion of the experiment.

TABLE 6

Solutions Pretest - Posttest Scores

Anova table for a 2-factor repeated measures Anova.

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Group Type-S (A)	1	35.633	35.633	2.467	.12
subjects w. groups	85	1227.827	14.445		
Repeated Measure (B)	1	531.126	531.126	119.655	.0001
AB	1	28.573	28.573	6.437	.013
B x subjects w. groups	85	377.3	4.439		

There were no missing cells found. 2 cases deleted with missing values.

The AB incidence table

Repeated Mea		Pretest S	Posttest	Totals:
Group Ty	Control	43 7.837	43 10.512	86 9.174
	Experimen	44 7.932	44 12.227	88 10.08
Totals		87 7.885	87 11.379	174 9.632

CHAPTER 4

CONCLUSIONS, RECOMMENDATIONS AND REFLECTIONS

CONCLUSIONS

Concept maps used as advance organizers are an amalgam of Ausubel's (1968) learning theory dealing with concept learning and Novak's (1984) instructional theory for using concept maps in classroom applications. Principal assumptions were that concepts are regularities amongst facts and are designated by a symbol arranged on a map. Also important to this study was the fact that meaningful concept learning will occur when the learner consciously tries to relate new information to concepts which already exist in the learner's cognitive structure, and meaningful learning is the goal of science education.

For the 89 grade seven students that took part in the experiment, involving two six-week units in science, ANOVA treatment of the pretest and posttest scores revealed that the experimental group using concept maps as advance organizers did significantly better in learning science material compared to the control group using the tradition textbook method. The hypothesis was accepted that concept maps used as advance organizers can significantly improve the learning of grade seven science material.

According to posttest scores, the experimental group scored about 7% better on the Living Things unit and about 9% better on the Solutions unit, compared to the control group. These results show significant gains and concur with other studies in science using concept maps as advance organizers: Cliburn (1985), Roth (1990), Kuhn and Novak (1970), Willerman and Mac Harg (1991). The findings of this study provide further support for Ausubel's model of learning and Joseph Novak's concept mapping heuristic.

RECOMMENDATIONS

Several recommendations have emerged from this study. Using a concept map in the context of an advance organizer is recommended as a way to encourage meaningful learning of science material.

Using a concept map as an advance organizer has implications not only for its applications in the classroom, but also for the advancement of the constructivist theory of learning. The researcher in getting the students to create their own maps involved them in a cooperative activity using a constructivist teaching model. This process is also a good way for teachers to develop curriculum. Hence, when a map is constructed a concrete product is available that can be copied, shared, and discussed with other colleagues. Sharing these products may encourage other teachers to learn about and use the constructivist approach to concept mapping to further their science teaching.

It takes a considerable amount of time to generate a concept map as an advance organizer. Like Cliburn (1990), I found at first it takes a huge amount of time, but the more one does it, the easier it becomes. Also, the procedure used to operationalize concept maps as advance organizers in this experiment is given in Chapter 3 and can be used by others as a guideline.

The students were probably helped by the teacher-produced concept maps because they helped with the organization and sequencing of material. Agreeably, the advantage of deliberately constructing an advance organizer is that only in this way can the learner enjoy the advantages of a subsumer which both (a) gives him a general overview of the more detailed material in advance of his actual confrontation with it, and (b) also provides organizational elements that are inclusive of and take into account most relevantly and efficiently both the particular content contained in this material and relevant concepts in cognitive structure (Ausubel, 1963, p. 82).

REFLECTIONS

Throughout this experiment a number of things were noted. The experimenter did not take a lot of time to formally teach the students the concept mapping strategy because he wanted to neutralize any concept mapping learning that would affect and influence the outcome when switching the control and experimental groups from unit one to unit two. Because of this some students found constructing the concept maps very difficult and confusing with regards to the real purpose and usefulness. More time on the usefulness and relationship between concept maps and learning would have been beneficial. However, as Novak (1991) stated: "It usually takes several months or regular practice and feedback in order to teach students how to construct good concept maps" (p. 48).

It was found, that in creating concept maps for the two units used in this experiment, a logistical concern that had a limiting effect on the maps was the actual size of the paper. The 8 1/2 by 11 inch paper only permitted the most important and major concepts to be used. Several other subordinate concepts could have been included but the space limitation prohibited this. Alternatively, for a large unit of study one general concept map and several relevant but inclusive concept maps may be a preference, as was utilized in the study conducted by Cliburn (1985).

The highly conceptual science program developed by SciencePlus 1 (ASCP, 1986) made extensive use of numerous scientific processes such as measuring, observing, recording, and interpreting, to name a few. The processes were not noted on the concept map but played a crucial role in introducing and integrating the numerous concepts involved in the units in the experiment.

Because a primary goal of education is to improve students' understanding and thinking skills, with the assertion the student is not just a passive consumer of information, constructivist learning theory goes hand-in-hand with cognitive learning. Both involve a process of adding information to what is already known. Johnson and Thomas (1992) established that students must "construct" their own meaning of their experiences based on what they currently know (p. 7). In order for meaningful learning to occur students must be active in their own learning. Therefore, in this way students are active participants in the planning, delivery, and evaluation of content material.

Notwithstanding, the teacher plays an active role in meaningful learning. If meaningful learning is to take place, the teachers plays a crucial role in that process. Concept mapping involves the teacher by examining the science content, picking out concepts, and arranging and sequencing the lessons and instructions in line with the concept maps.

Educators are constantly searching for effective tools to make teaching and learning more effective and interesting. Also, given the economic situation surrounding education, teachers must search out inexpensive and effective techniques. Concept mapping takes no more than paper, pencil, and instruction time. It requires minimal training time, little investment in materials, and no investment in equipment.

Additionally, the use of concept maps or advance organizers does not require teachers to change their pedagogical style; these can serve as an addition to their present technique of teaching.

As a pre-instruction tool, the concept map is a valuable alternative, or addition, to other techniques such as an informal interview, questions and answers, or a pretest, to determine what prior knowledge a student has regarding a particular topic.

The experimenter also concurs with the recommendation made by Barnes and Clawson (1975) that future advance organizer research studies last more than a week, be used with students other than at the college level, and be conducted in a direct classroom setting. This study, which lasted for twelve weeks and was applied to students at the grade seven level of a junior high school, adds to the ongoing research on advance organizers.

One more improvement that should be encouraged and taken advantage of is using the microcomputer. As was noted by Heinze-Fry, Crovello, & Novak (1984): "we are at the beginning of computer assisted education" (p. 153). An area that holds a lot of potential is educomputing. The microcomputer can excite students both cognitively and affectively, and science is but just one area where subject content and interactive concept mapping can be adapted to software and computer technology. This direction should be explored more!

Moreover, more graphics should be integrated into the concept mapping process in order make the material more vivid in the learners mind. Zil'bershtein (1963), in an article on visual aids and pupil stimulation, suggested: "Various means of visual education such as natural objects, pictures, models, charts, maps or diagrams may and must be used to develop analytical thought and synthesis in order to make it easier for students to understand generalizations in the form of scientific concepts" (p. 35-36).

In education more emphasis should be placed on meaningful learning. As Cliburn (1986) suggests, science should be treated as a body of knowledge and, in the process of teaching, the material should be presented in a meaningful manner. To this end, the teachers' should understand and present their subject as a conceptual system in order to allow for meaningful learning.

The researcher tested for the learning of science material. Like Roth (1990); Roth and Yore (1992) the author noticed increased enthusiasm, an eagerness for work, and greater classroom productivity with the experimental group that used concept maps.

In summary, research seems to indicate that concept mapping is an important strategy for several reasons. First, the student must be an active participant in the learning process. Second, mapping requires the student to process the information at a deeper level. Third, the student may obtain an overall picture of the information, not just bits and pieces of disjointed and unconnected information. Thus, the student obtains a cognitive framework from which to proceed in the learning process.

Concept maps as advance organizers are powerful teaching strategies that require students to become active and responsible learners. The achievement gains shown in this study confirm that concept maps used as advance organizers can significantly increase the learning of grade seven science material.

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APPENDIX A

LIVING THINGS UNIT

TEACHER CONCEPT MAP

STUDENT CONCEPT MAP

PRETEST

POSTTEST

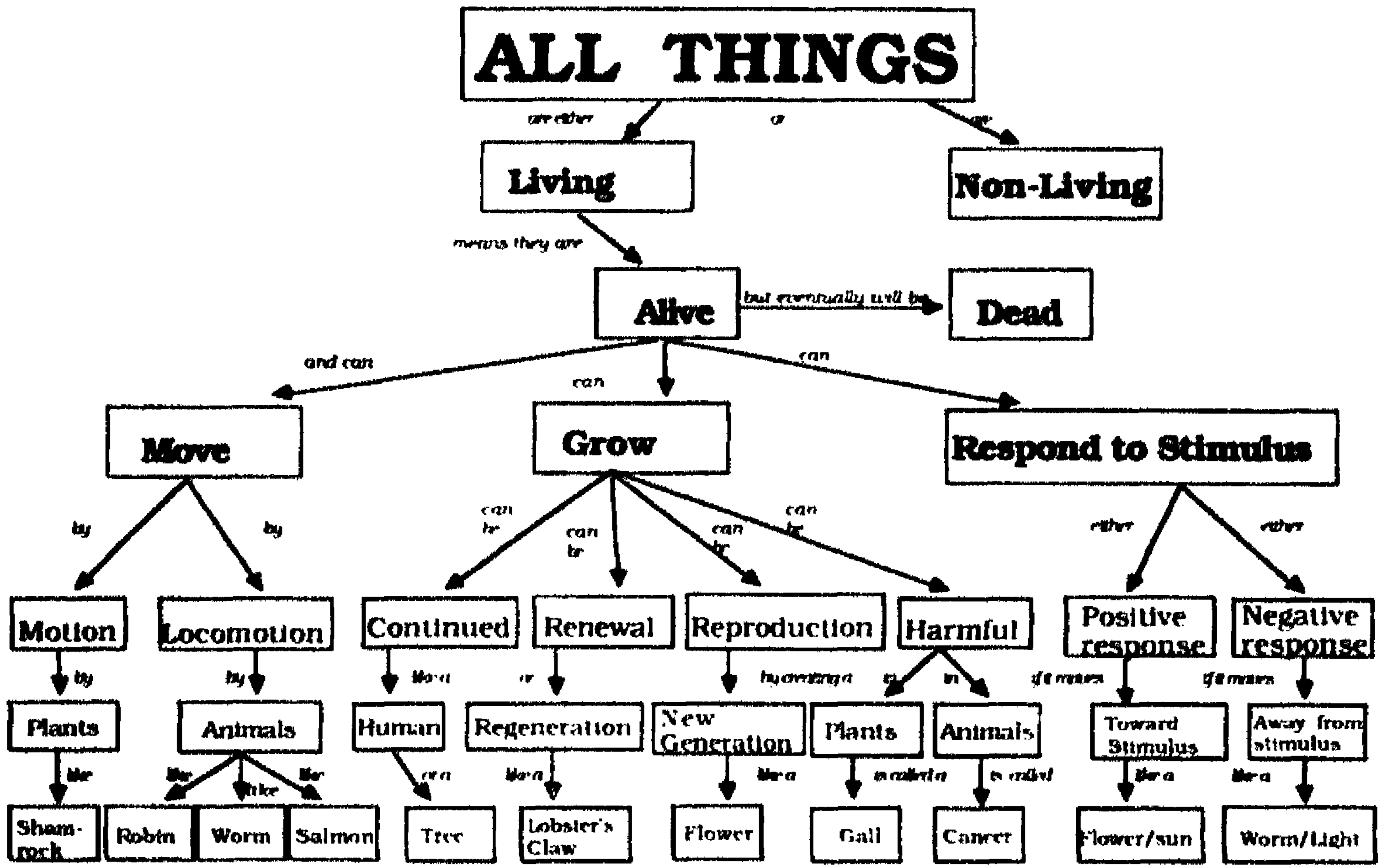


Figure 1. Teacher Concept Map-Living Things Unit

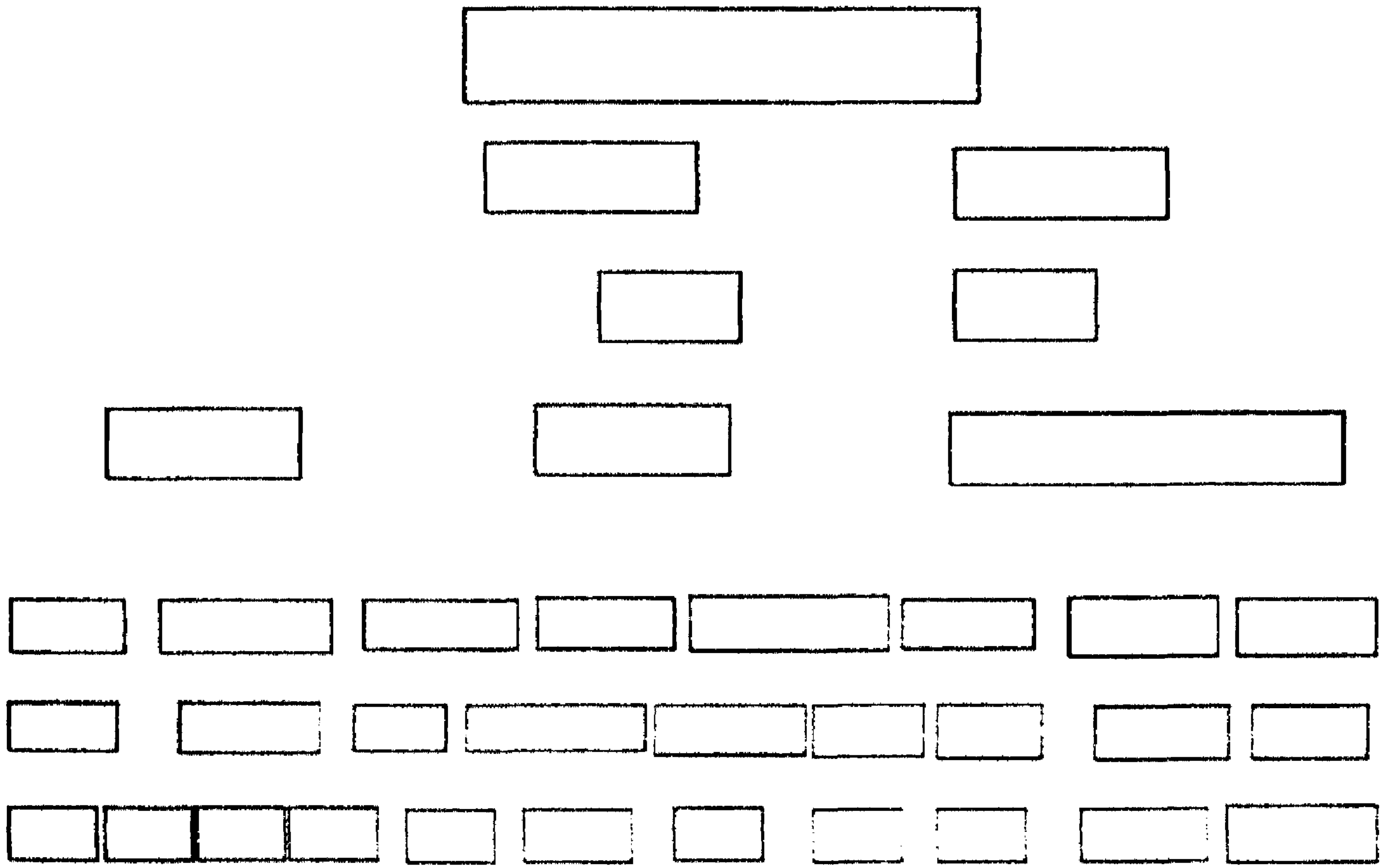


Figure 2. Student Concept Map-Living Things Unit

GRADE 7 LIVING THINGS PRETEST

INSTRUCTIONS:

1. THERE ARE 20 MULTIPLE-CHOICE QUESTIONS.
2. PLEASE READ EACH QUESTION CAREFULLY.
3. CHOOSE THE CORRECT OR BEST ANSWER.
4. ON THE ANSWER SHEET PLACE THE LETTER IN THE BLANK THAT BEST ANSWERS THE QUESTION.
5. BE SURE THE NUMBER ON THE ANSWER SHEET MATCHES THE NUMBER OF THE QUESTION YOU ARE ANSWERING.
6. MARK ONLY ONE ANSWER FOR EACH QUESTION.

EXAMPLE: ANSWER SHEET

1. THIS IS FOR THE SUBJECT OF 1. __A__

A. SCIENCE
B. MATHEMATICS
C. ENGLISH
D. HEALTH

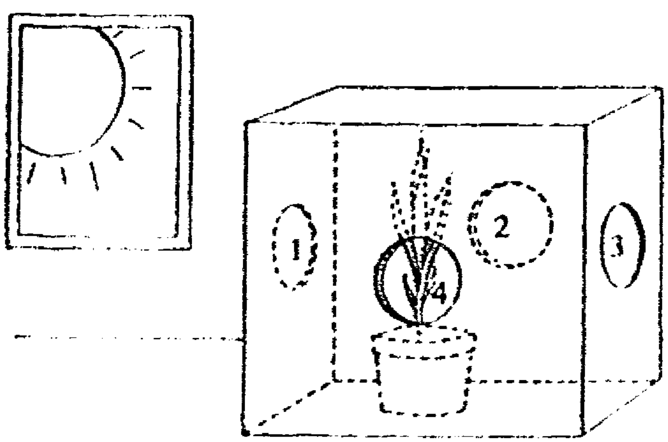
GOOD LUCK

1. An example of a non-living part of an ecosystem is

A. moss
B. mold
C. water
D. bacteria

Use the following information to answer question 2.

Ryan cut an identical hole in four sides of a large box. He placed the box over a plant as shown in the diagram.



2. <u>Predict</u> which hole the plant's leaves would face at the end of one week.

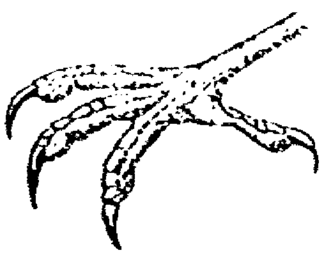
A. 1
B. 2
C. 3
D. 4

3. If an animal has six legs, two pairs of wings, and a body with a head, thorax, and abdomen, which of the following could this animal be?

A. a bird
B. a spider
C. a butterfly
D. a bat

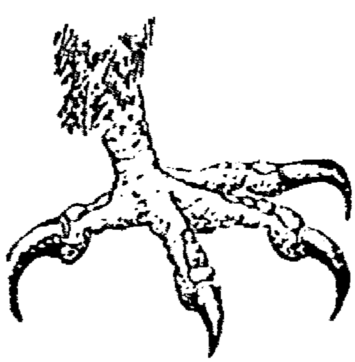
4. Which bird's foot is <u>best</u> adapted for running?

A.

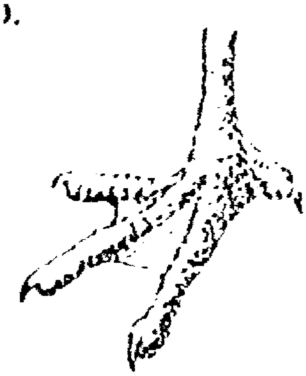


B.

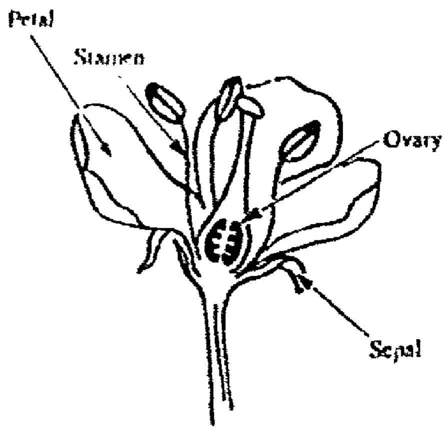
C.



D.



Questions 5 and 6 refer to the diagram of the flower below.



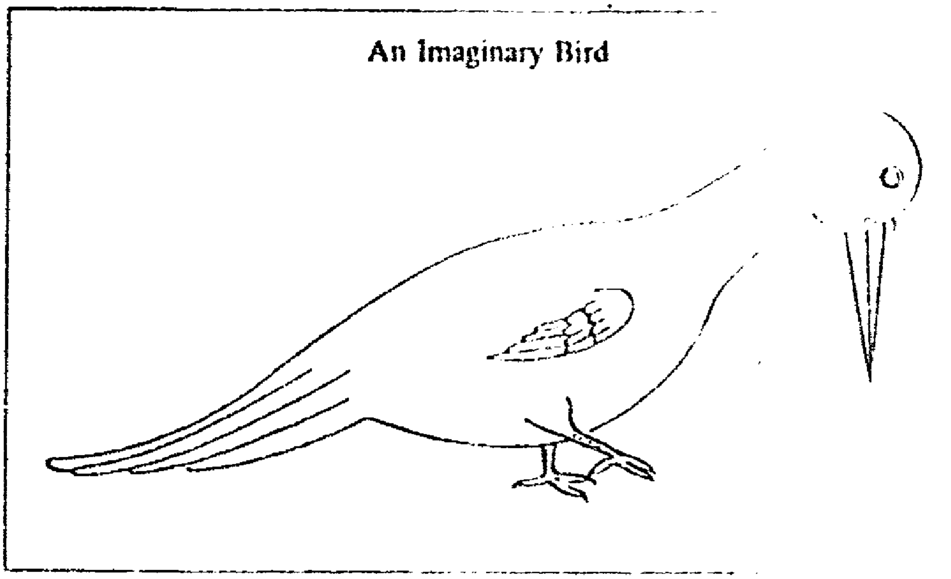
5. What part of the flower produces pollen?

A. petal
B. stamen
C. ovary
D. sepal

6. What part of the flower produces seeds?

A. petal
B. stamen
C. ovary
D. sepal

Use the following diagram to answer question 7



7. Based on this imaginary bird's physical characteristics, the <u>best</u> inference is that it

A. wades along lake shores in search of food
B. soars and glides on wind currents
C. swims in ponds and marshes
D. feeds on worms and grubs

THE GREAT WORM RACE BETWEEN ALPHA, BETA, AND GAMMA

8. Three worms started from the center of the ring. Alpha sped outwards at 50 cm/h for the first half-hour. During the last half-hour his speed was only 30 cm/h. Beta, on the other hand, started out slowly; during the first half-hour her speed outward was only 20 cm/h. However, in the final half-hour she sped out at 70 cm/h. Gamma had a steady pace for the full hour, averaging 40 cm/h.

How far did the winner go?

A. 40
B. 45
C. 35
D. 50

9. Which of the following is an example of locomotion?

A. An empty sled sliding down a hill.
B. A person pulling a sled up a hill.
C. A person rolling down a hill after falling off a sled.
D. A person climbing a hill on a snowmobile.

10. To make food, green plants need light,

A. oxygen and water.
B. oxygen and carbon dioxide.
C. carbon dioxide and carbohydrates.
D. carbon dioxide and water.

11. Which of the following best explains why rabbits turn white in winter?

A. To help them find food.
B. To help them keep warm.,
C. To be less visible to predators.
D. To reduce their body temperatures.

12. Everything around us can fit into one of these groups

A. non-existent, alive, different
B. living, non-existent, dead
C. different, dead, non-living
D living, dead, non-living

Use the following picture to answer question 13

13. This picture is an example of

A. positive response
B. positive stimulus
C. negative stimulus
D. negative response

14. A type of harmful growth usually found on the stem a plant is a

A. cancer
B. sore
C. gall
D. wart

15. One difference between animals and plants is

A. Animals move by locomotion.
B. Animals need water.
C. Animals reproduce.
D. Animals grow.

16. Which is not a living thing

A. tree
B. bird
C. nest
D. leaf

Use the following diagram to answer question 17

17. The creature seems related to

A. scorpions.
B. insects.
C. spiders.
D. centipedes.

18. Which is the main difference between insects and birds?

A. wings
B. feathers
C. eggs
D. eyes

19. Elena finds the following items scattered in her garage:

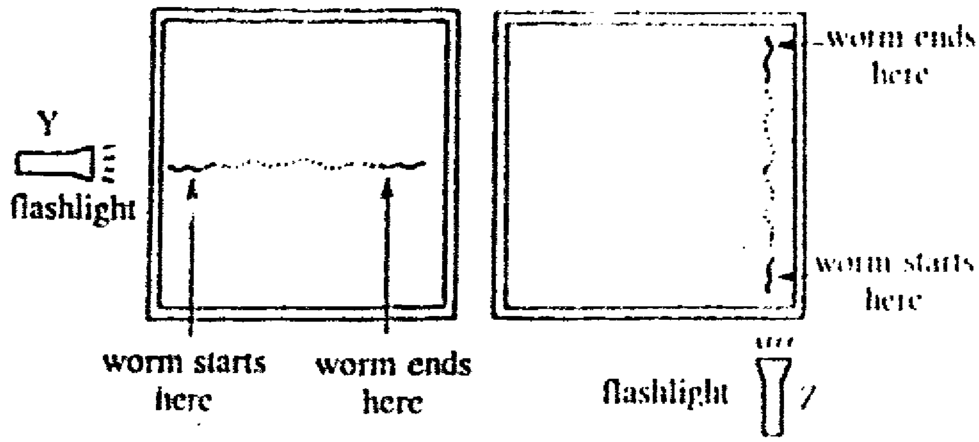
. hammer	. soccer ball	. piece of wood
. baseball	. screwdriver	. football helmet
. brick	. saw	. flea

How many living things did she find?

A. 0
B. 4
C. 2
D. 1

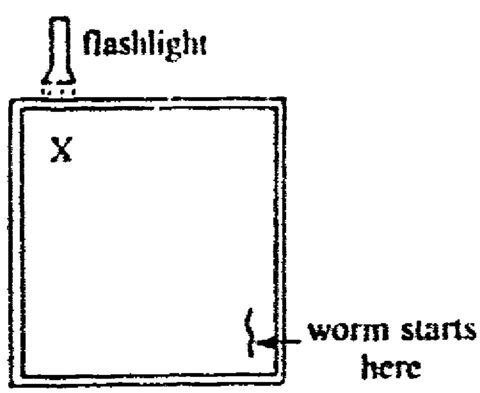
Use the following information to answer question 20

Sarah shone a flashlight on an earthworm and watched where the worm moved. The diagrams show from above what happened when she placed the flashlight at Y and at Z.

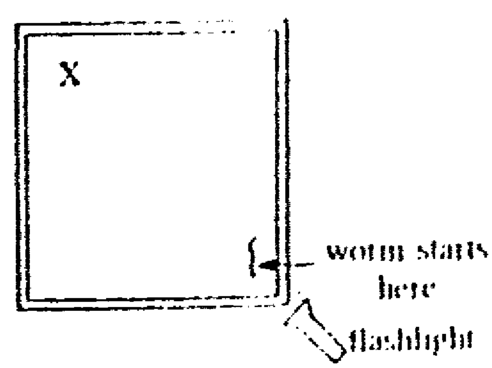


20. If Sarah wanted to move the worm to X, predict where the best place for her to position the flashlight would be.

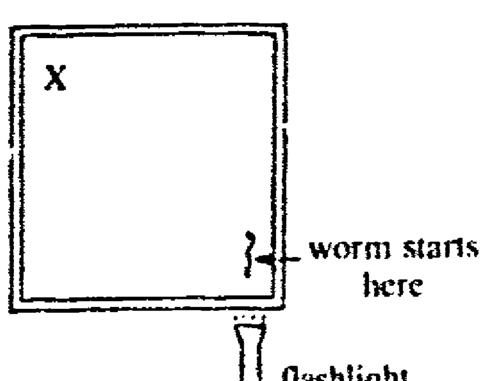
A.



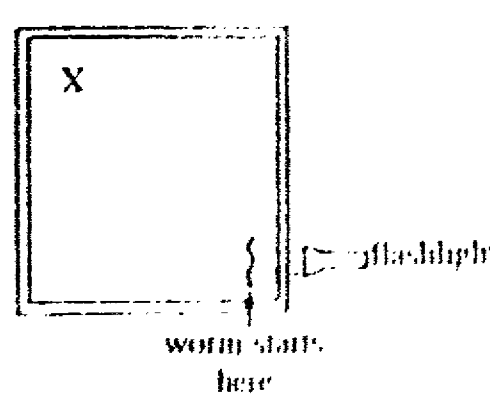
B.



C.



D.



ANSWER SHEET

NAME: ______________________ CLASS: __________

1. ______
2. ______
3. ______
4. ______
5. ______
6. ______
7. ______
8. ______
9. ______
10. ______
11. ______
12. ______
13. ______
14. ______
15. ______
16. ______
17. ______
18. ______
19. ______
20. ______

GRADE 7 LIVING THINGS POSTTEST

INSTRUCTIONS:

1. THERE ARE 20 MULTIPLE-CHOICE QUESTIONS.
2. PLEASE READ EACH QUESTION CAREFULLY.
3. CHOOSE THE CORRECT OR BEST ANSWER.
4. ON THE ANSWER SHEET PLACE THE LETTER IN THE BLANK THAT BEST ANSWERS THE QUESTION
5. BE SURE THE NUMBER ON THE ANSWER SHEET MATCHES THE NUMBER OF THE QUESTION YOU ARE ANSWERING.
6. MARK ONLY ONE ANSWER FOR EACH QUESTION.

EXAMPLE: ANSWER SHEET

1. THIS IS FOR THE SUBJECT OF 1. _A_

A. SCIENCE
B. MATHEMATICS
C. ENGLISH
D. HEALTH

GOOD LUCK

1. An example of a non-living thing in our environment is:

A. mushroom
B. fern
C. air
D. virus

2. Four types of growth that living things may exhibit are:

A. continued, replacement, reproduction, harmful
B. continued, renewal, reproduction, harmful,
C. regeneration, continued, harmful, renewal
D. rejuvenation, continued, harmful, regeneration

3. While a girl was sitting under a tree, she watched a bird getting insects from between the cracks of the bark. Which drawing shows the kind of beak this bird most likely had?

A


B


C


D


4. The female reproductive structure of the flower is:

A. stamen
B. sepal
C. pistil
D. anther

EARTHWORM OLYMPICS

5. During the Earthworm Olympics six earthworms started from the center of the ring. In one minute **Nothin'** traveled 44 cm., while **Earl** finished in second place by squirming 37 cm. Finishing in third place was **Reggie** with 34 cm; just behind was **Butch** who crawled 30 cm, and **Boo Boo** next at 29 cm. **Jerome** finished in sixth place with 27 cm.

What was the average distance traveled by the worms?

A. 34 cm
B. 33.5 cm
C. 33 cm
D. 32.5 cm

6. How do insects help many types of plants?

A. they bring food for the plants
B. they carry pollen.
C. they lay eggs inside the plants.
D. they eat the leaves of the plants.

7. Which is **not** a dead thing?

A. grass
B. paper
C. chair
D. wood

8. When do girls get a large growth spurt?

A. 11-15
B. 10-16
C. 16-21
D. 12-17

9. A type of harmful growth found in animals is:

A. gall
B. wart
C. sore
D. cancer

10. All living things show these signs of life:

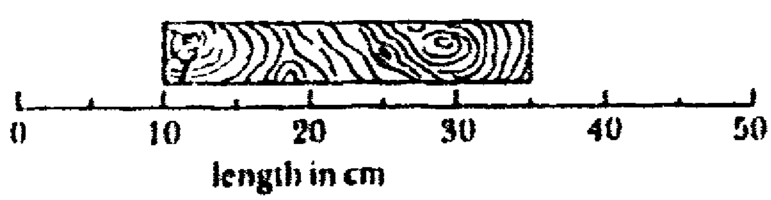
A. rejuvenates, migrates, and responds to stimulus
B. breaths air, reproduces, and grows stronger
C. moves, grows, and responds to stimulus
D. eats meat, hibernates, and grows

11. Fertilization occurs in a flowering plant when:

A. pollen grains travel down the stamen
B. pollen is attached to the pistil
C. a seed sprouts roots and a stem
D. a pollen grain unites with an egg

12. An essential function of adult insects is to:

A. migrate
B. reproduce
C. grow quickly
D. hibernate



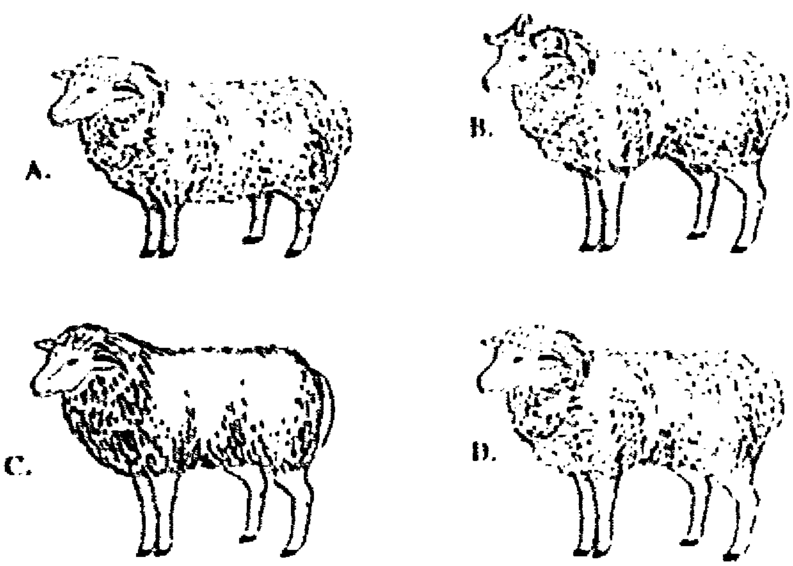
13. How long is the block of wood shown in the above diagram?

A. 35 cm
B. 25 cm
C. 30 cm
D. 20 cm

14. Which of the following is an example of motion?

A. someone picks up a plant and moves it close to the window
B. leaves fall from a tree in the fall
C. bean seedlings bend toward the light when placed by a sunny window
D. petals fall off a flower

15. A farmer wants to select sheep that are not likely to jump the fences in the farmyard. Which sheep should the farmer select?



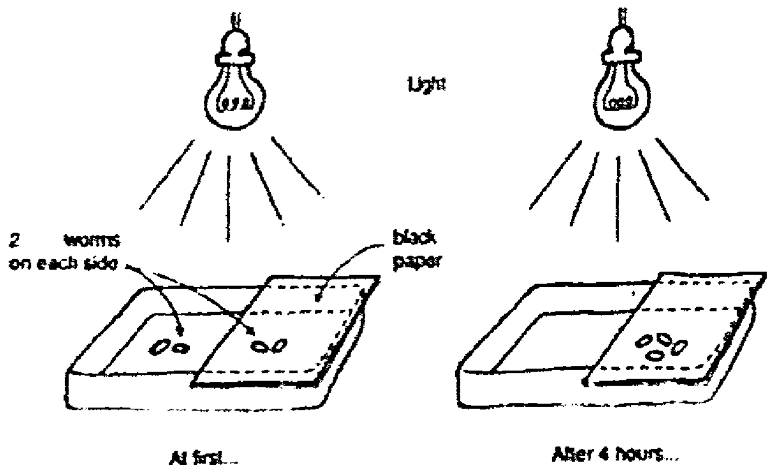
16. One key difference between plants and animals is:

A. only animals can reproduce a new generation
B. only plants can produce another one of its kind
C. only plants can move from one place to another
D. only animals can move from place to place

17. Which is not a warm-blooded animal?

A. rabbit
B. frog
C. deer
D. crow

18. An experiment was done to test the responses of an earthworm to light. The apparatus was set up as in the diagram below. Note the position of the worms after 4 hours of illumination.



Which statement best explains or infers what you have observed in this experiment?

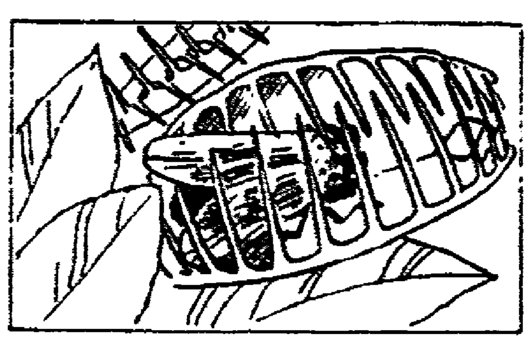
A. the worms liked being together
B. the worms preferred the bright area to the dark one
C. the worms preferred a dark area to a bright one
D. the worms preferred a warmer spot to a colder one

19. Which of the following best explains why rabbits turn white in the winter?

A. to help them find food
B. to help them keep warm
C. to be less visible to its enemies
D. to reduce their body temperature

20. This venus flytrap is an example of:

A. stimulus
B. reaction
C. positive response
D. negative response



ANSWER SHEET

NAME: ______________________ CLASS: ____ _____

1. ______
2. ______
3. ______
4. ______
5. ______
6. ______
7. ______
8. ______
9. ______
10. ______
11. ______
12. ______
13. ______
14. ______
15. ______
16. ______
17. ______
18. ______
19. ______
20. ______

APPENDIX B

SOLUTIONS UNIT

TEACHER CONCEPT MAP

STUDENT CONCEPT MAP

PRETEST

POSTTEST

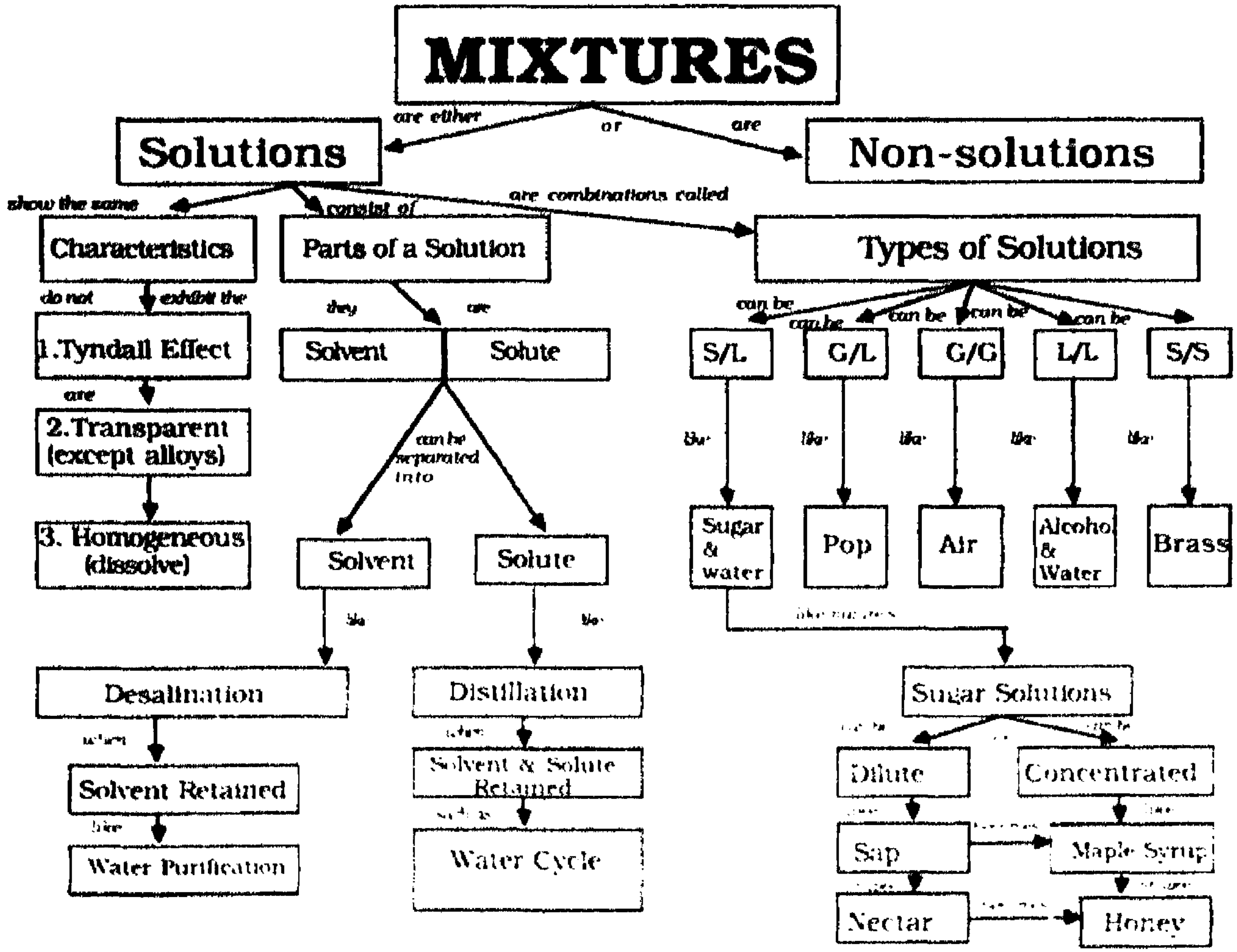


Figure 3. Teacher Concept Map-Solutions Unit

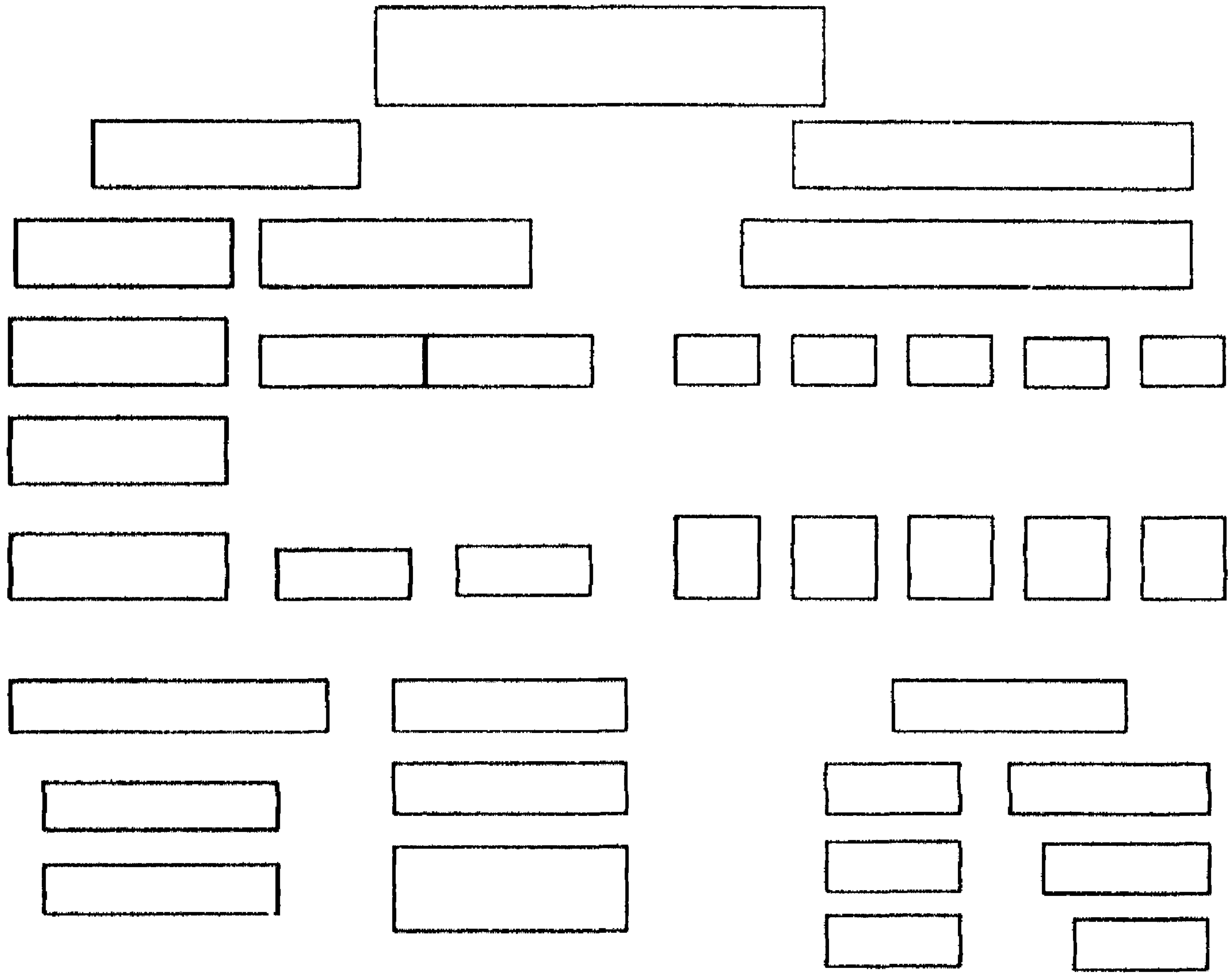


Figure 4. Student Concept Map-Solutions Unit

GRADE 7 SOLUTIONS PRETEST

INSTRUCTIONS:

1. THERE ARE 20 MULTIPLE-CHOICE QUESTIONS.
2. PLEASE READ EACH QUESTION CAREFULLY.
3. CHOOSE THE CORRECT OR BEST ANSWER.
4. ON THE ANSWER SHEET PLACE THE LETTER IN THE BLANK THAT BEST ANSWERS THE QUESTION.
5. BE SURE THE NUMBER ON THE ANSWER SHEET MATCHES THE NUMBER OF THE QUESTION YOU ARE ANSWERING.
6. MARK ONLY ONE ANSWER FOR EACH QUESTION.

EXAMPLE: ANSWER SHEET

1. THIS IS FOR THE SUBJECT OF: 1. __A__

A. SCIENCE
B. MATHEMATICS
C. ENGLISH
D. HEALTH

GOOD LUCK

1. Which of the following does not dissolve in water?

A. salt
B. sugar
C. alcohol
D. oil

2. A student dissolves some sugar in a container of water. Which of the following actions will NOT increase the rate at which the sugar dissolves?

A. heating the water
B. crushing the sugar
C. stirring the sugar
D. closing the container

3. If the molecules of a substance are moving at great distances from each other in comparison with the size of the molecules and interact weakly with each other, what is the state of this substance?

A. a crystal
B. a liquid
C. a solid
D. a gas

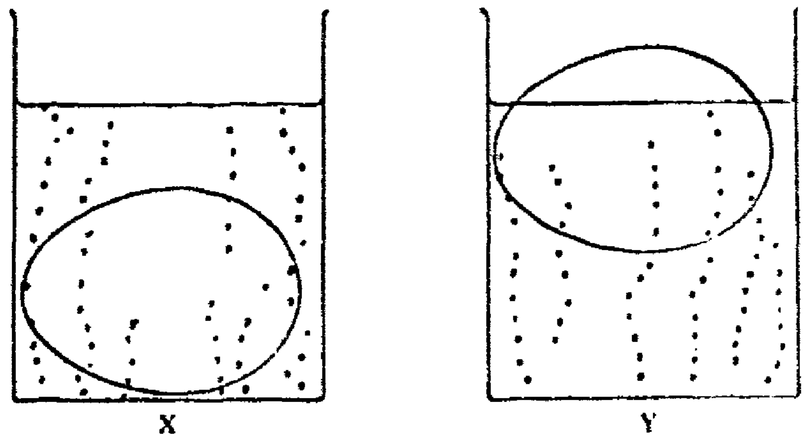
4. Which symbol identifies a substance as corrosive?

A. B. C. D.

5. An instrument used to find the concentration of a liquid solution is:

A. hydrometer
B. thermometer
C. pedometer
D. odometer

6. Mary placed an egg in each beaker.

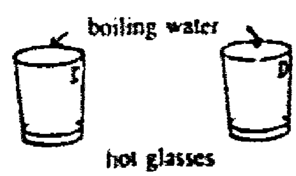


An **observation** to be made from the pictures is that

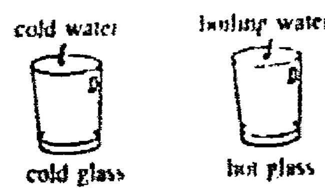
A. the egg in beaker Y is floating
B. the liquid in beaker Y is cooler
C. there is a salt solution in beaker Y
D. the egg in beaker Y has a smaller mass

7. When John poured boiling water into a glass, the glass broke. He thought that the great difference in temperature between the water and the glass caused the glass to break. Which of the following would be the **BEST** test of his hypothesis?

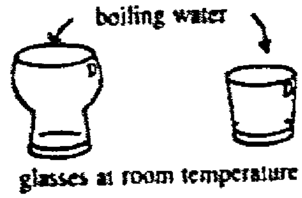
A.



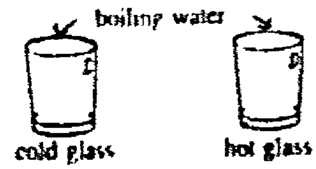
B.



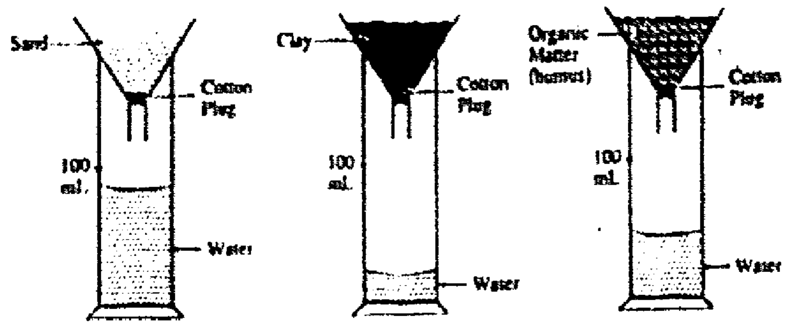
C.



D.

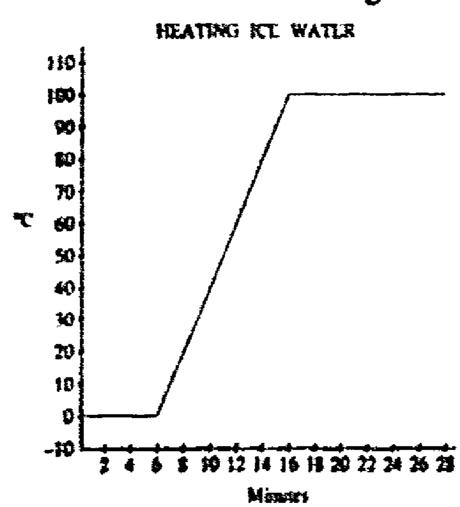


8. A student pours 100 ml of water into each of three funnels. Each funnel contains a different substance. The student waits until the water stops flowing out of all the funnels, and obtains the results shown in the diagrams below. What can this student correctly conclude from these results?



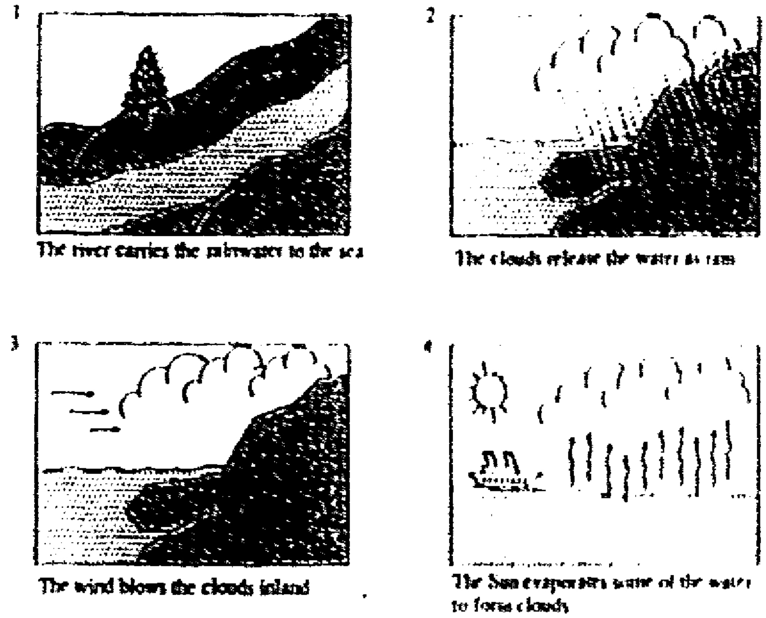
A. The sand absorbs more water than the humus does.
B. The clay absorbs more water than the sand or the humus does.
C. The clay absorbs all of the water that is poured into the funnel.
D. The sand does not absorb any water.

9. A beaker containing crushed ice and water is heated. The temperature of the beaker's contents is recorded every 2 minutes. A graph of the data appears below. When does boiling of the contents of the beaker occur?



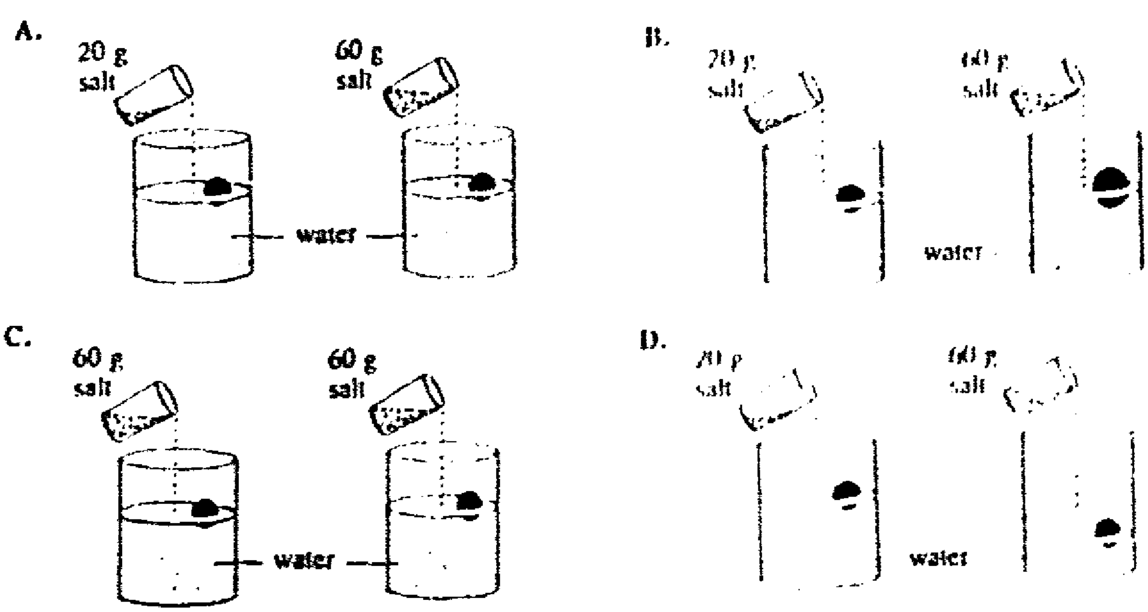
A. Immediately after the heating begins
B. Between 2 and 6 minutes after the heating begins
C. Between 8 and 14 minutes after the heating begins
D. After 16 minutes of heating

10. **For the diagrams below, which of the following is the correct order for the water cycle?**



A. 4 ---> 2 ---> 3 ---> 1
B. 4 ---> 1 ---> 3 ---> 2
C. 4 ---> 1 ---> 2 ---> 3
D. 4 ---> 3 ---> 2 ---> 1

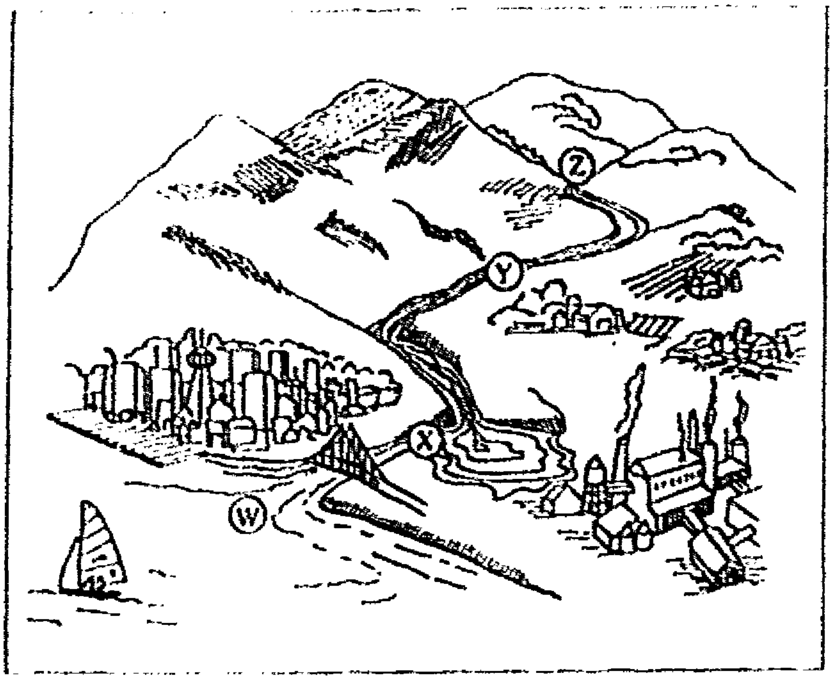
11. **Mary wants to find out if the amount of salt added to water affects how high a ball will float in water. Which experimental design would be the best for her to use?**



12. **If a mixture shows the tyndall effect it is called**

A. a solution
B. a non-solution
C. a solvent
D. a solute

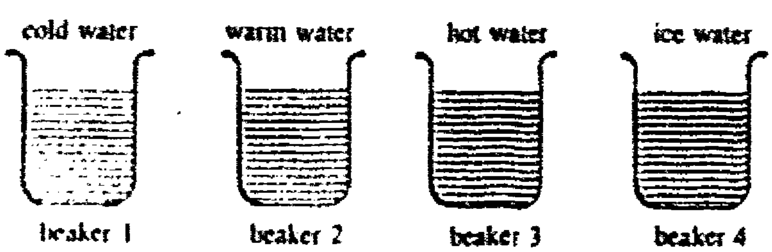
13. Scientists would **most** likely observe that the river water would be least polluted at the place marked in the picture with the letter



A. W
B. X
C. Y
D. Z

Use the following information to answer question 14.

Equal amounts of water were placed in each of four beakers. The beakers were kept at different temperatures.



14. After one day, which beaker would have the **least** amount of water in it?

A. Beaker 1
B. Beaker 2
C. Beaker 3
D. Beaker 4

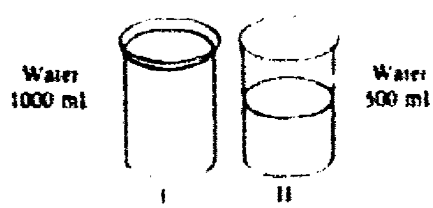
Use the following information to answer question 15.

One morning, Patricia tossed a beach ball into a pail. When she returned in the hot afternoon, she had difficulty removing the beach ball from the pail.

15. The **best** explanation for this is that the

A. ball and pail had expanded
B. ball and pail had contracted
C. ball had expanded more than the pail
D. pail had contracted more than the ball

Use the following information to answer question 16.



16. Which of the following statements about raising the water temperature from 20 degrees Celsius to 80 degrees Celsius in the beakers above is true?

A. The same amount of heat must be added to both beakers.
B. More heat must be added to beaker I.
C. More heat must be added to beaker II.
D. The temperature of beaker I will rise twice as fast as beaker II.

17. Of these maple products, which has the highest concentration of sugar?

A. maple sap
B. maple butter
C. maple wax
D. maple syrup

18. Sara dissolves some sugar in a pot of water. How can she recover solid sugar from this solution?

A. By pouring the solution through a paper filter
B. By heating the solution and then collecting the sugar that is left in the pot after the water has evaporated
C. By using a magnet to attract the sugar
D. By allowing the solution to stand for a few hours and then collecting the sugar that has sunk to the bottom of the pot

19. Pop (club soda) is an example of which type of solution?

A. gas - gas
B. solid - liquid
C. solid - solid
D. gas - liquid

20. In a solution of instant coffee and water, the water is known as what part of the solution?

A. solvent
B. solute
C. soluble
D. saturated

ANSWER SHEET

NAME: ______________________ CLASS:_____

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GRADE 7 SOLUTIONS POSTTEST

INSTRUCTIONS:

1. THERE ARE 20 MULTIPLE-CHOICE QUESTIONS.
2. PLEASE READ EACH QUESTION CAREFULLY.
3. CHOOSE THE CORRECT OR BEST ANSWER.
4. ON THE ANSWER SHEET PLACE THE LETTER IN THE BLANK THAT BEST ANSWERS THE QUESTION.
5. BE SURE THE NUMBER ON THE ANSWER SHEET MATCHES THE NUMBER OF THE QUESTION YOU ARE ANSWERING.
6. MARK ONLY ONE ANSWER FOR EACH QUESTION.

EXAMPLE: ANSWER SHEET

1. THIS IS FOR THE SUBJECT OF: 1. __A__.

A. SCIENCE
B. MATHEMATICS
C. ENGLISH
D. HEALTH

GOOD LUCK

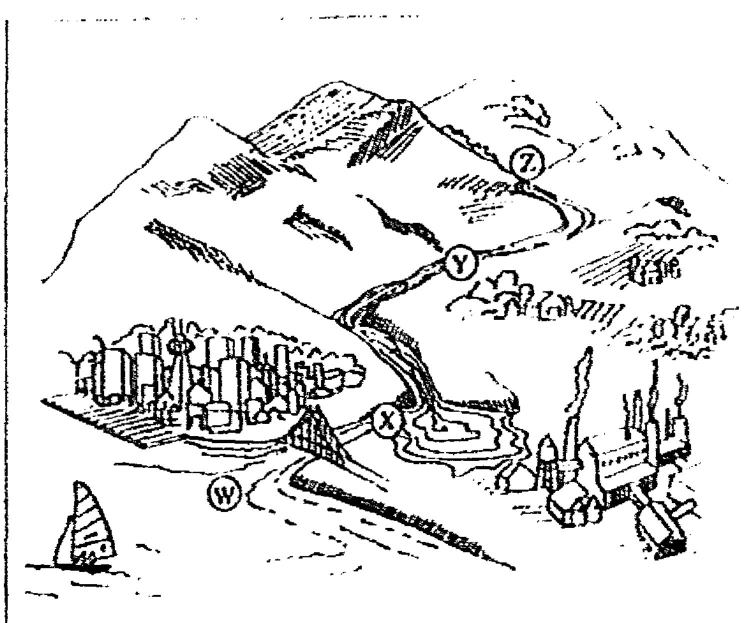
1. The best way to separate a mixture of table salt and beach sand would be to:

A. put the mixture in a beaker and heat it in a bunsen burner.
B. put the mixture in a filtered funnel and run water through the mixture.
C. pass a strong magnet over the mixture.
D. add dilute calcium chloride solution and stir until the bubbles of gas are no longer escaping.

2. Air is an example of which type of mixture?

A. gas - liquid
B. solid - solid
C. gas - gas
D. solid - liquid

3. Scientists would most likely observe that the river would be <u>most</u> polluted at the place marked in the picture with the letter



A. W
B. X
C. Y
D. Z

4. In a solution of water and sugar, the sugar is known as what part of the solution?

A. saturated
B. solvent
C. soluble
D. solute

5. Of these maple products which is the most dilute solution?

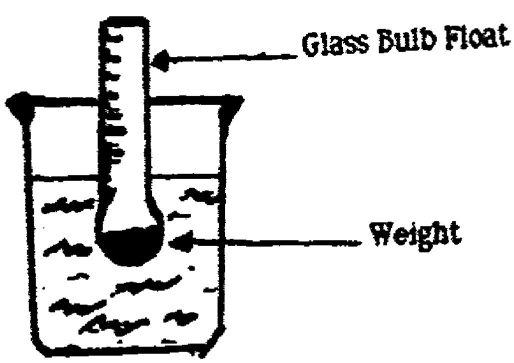
A. maple syrup
B. maple wax
C. maple sap
D. maple butter

6. If a mixture does not show the tyndall effect it is called

A. a solid
B. a solution
C. a non-solution
D. a liquid

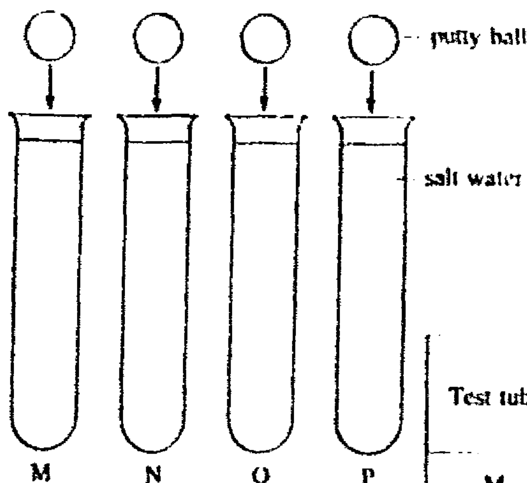
7. An instrument to test the saltiness of water can be made by placing a small weight at the bottom of a sealed glass bulb, and floating this bulb in the water as shown in the diagram. What would you expect to happen to the float if more salt is added to the water?

A. floats to a higher level
B. sinks to a lower level
C. Water rises inside the bulb
D. stops at the same level



Use the following information to answer question 8.

John set up four identical test tubes of water at the same temperature. Each contained different amounts of dissolved salt. Into each test tube John dropped an identical ball of putty. He recorded on a chart the time it took the putty to settle to the bottom of the test tube.



Test tube	Time to settle in seconds (s)
M	4
N	6
O	5
P	7

8. The variable that probably influenced the result shown on John's chart is the

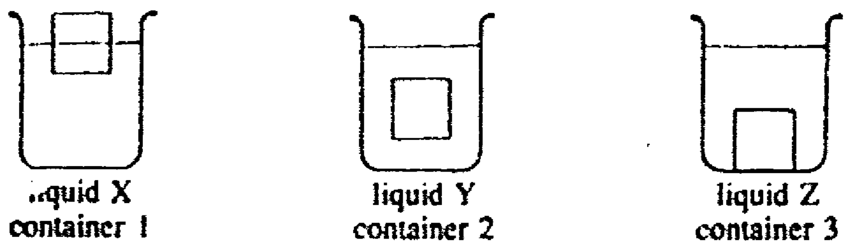
A. amount of salt
B. mass of the putty balls
C. temperature of the water
D. diameter of the test tubes

9. Which situation is an example of condensation?

A. Dew drops disappear from a leaf.
B. Susan feels cold when she gets out of the bathtub.
C. Drops of water form on the outside of a cold glass.
D. The water on a glass decreases in volume sitting on the counter.

Use the following information to answer question 10.

Jessica completed the following experiment. Into the first of three identical containers, she poured 500 mL of liquid X. She poured 500 mL of liquid Y into container 2 and 500 mL of liquid Z into container 3. Jessica then placed an ice cube in each container. The ice cubes were of equal size, shape, and mass. The diagrams show what occurred.



10. The best observation Jessica could make is that the ice cube floated in liquid

A. X but sank in liquid Z
B. X but sank in liquid Y
C. Z but sank in liquid Y
D. Z but sank in liquid X

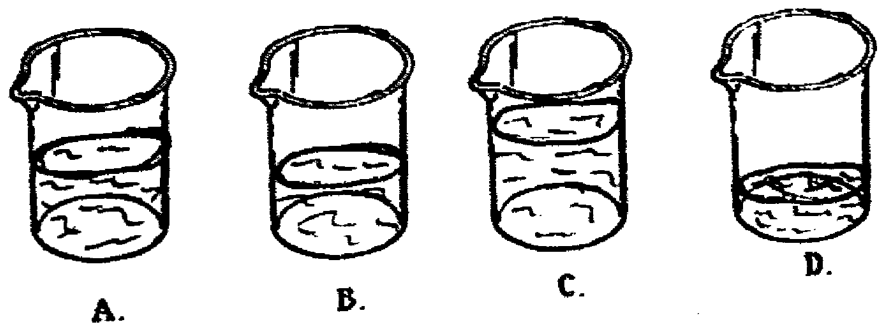
11. The largest amount of solute that can be dissolved in a solvent is its

A. solution
B. solubility
C. density
D. mass

12. A saturated solution is a mixture that

A. has very little solute
B. can still hold a little more solute
C. has all the solute it can hold
D. has no solute

13. **If each beaker contains 5 grams of sugar, which is the most <u>concentrated</u> solution?**



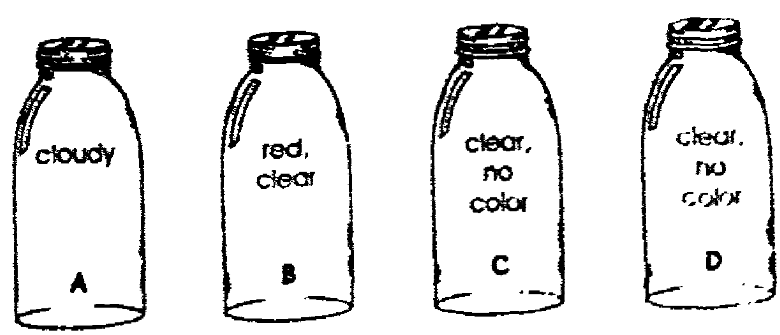
14. An alloy of manganese bronze is made up of 1% tin, 1.5% iron, 39% zinc, and 58.5% copper. What is the solvent?

A. copper
B. tin
C. zinc
D. iron

15. Which is <u>not</u> a characteristic of a solution?

A. homogeneous
B. transparent (except alloys)
C. does not show the tyndall effect
D. all contain liquids

16. Allan is given four bottles filled with liquid, as shown below. Which can you say for sure is <u>not</u> a solution?



17. Solutions and non-solutions are both known as

A. mixtures
B. concentrates
C. alloys
D. solubles

18. Which is not a term to describe the water cycle?

A. evaporation
B. purification
C. precipitation
D. condensation

Use the following information to answer question 19.

The maximum amount of different solutes (in grams) that can be dissolved in 100 g of water at different temperatures is given here.

	Temperature					
Substance	0°C	10°C	20°C	30°C	40°C	50°C
Table salt (sodium chloride) (a solid)	35.7	35.8	36.0	36.3	36.6	37.0
Potassium chloride (a solid)	27.6	31.0	34.0	37.0	40.0	42.6
Sugar, (sucrose) (a solid)	179.0	191.0	204.0	220.0	238.0	260.0
Sulphur dioxide (a gas)	22.8	16.2	11.3	7.8	5.4	4.5
Oxygen (a gas)	0.0070	0.0054	0.0044	0.0037	0.0033	0.0030

19. Which substance is more soluble at 20 degrees celsius?

A. table salt
B. oxygen
C. sugar
D. potassium chloride

20. All solutions, except solid / solid solutions

A. are liquid
B. are transparent
C. show the tyndall effect
D. are saturated

ANSWER SHEET

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