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AUTHOR Okebukola, Peter Akinsola; And Others
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ABSTRACT

This paper provides a brief review of research on concept mapping in biology at the college level that has addressed the issues of "conceptual transparency" and "learner friendliness." For many college students, biology is "conceptually opaque." Students may memorize the characteristics of a plant, but find it difficult to identify that plant in their local environment. Categories of this paper include: (1) theoretical underpinnings and mechanics of concept mapping; (2) uses of concept maps in college science; and (3) concluding thoughts. (PR)

# MAKING COLLEGE SCIENCE TRANSPARENT THROUGH THE USE OF CONCEPT MAPS

**Peter Akinsola Okebukola**

Faculty of Education, Lagos State University, PMB 1087, Apapa, Lagos, NIGERIA

&

**Rose Nkechi Agholor**

Science and Mathematics Education Centre, Curtin University of Technology

Perth 6001, WESTERN AUSTRALIA

**Olugbemiro J. Jegede**

Distance Education Centre, University of Southern Queensland

Toowoomba, QLD 4350, AUSTRALIA

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## Introduction

Writing in the *Journal of College Science Teaching* about a decade ago, Penick and Kyle (1982) conclude that "for mankind, the future will present many problems that will be biological in nature..." Jegede (1990) further hints that a "sound education in biology as a component of broad scientific literacy, will be a prerequisite for successful living in the third millenium". Indications that these conjectures will hold true are provided by recent advances in science. It is on this basis that Roger (1990) pleads that "biology should be made 'learner friendly' especially for college students who will be making policies in the first half of the next century".

Although regarded as the softest option of the sciences, many college students still find biology to be "conceptually opaque". In the taxonomy class, they memorize the characteristics of animal and plant groups but find it difficult to identify and classify organisms in their local environment. Genetics is taken to be abstract. So also ecology, nervous system and homeostasis. Concept mapping is appearing on the scene as a technique with a great potential for improving the teaching and learning of biology by bring about "conceptual transparency" and "learner friendliness". This paper provides a brief review of research on concept mapping in biology at the college level that have addressed the issues of "conceptual transparency" and "learner friendliness".

## Theoretical underpinning and mechanics of concept mapping

Basic to discussions on concept mapping is the explication of the meaning of the word "concept". Novak's (1991) definition comes in useful here. According to him, a concept is perceived regularity in events or objects, or records of events or objects designated by a label.

The technique of concept mapping is undergirded by Ausubel's (1968) assimilation theory. The assertion of Ausubel that "If I had to reduce all of education psychology to just one principle, I would say this: The most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly" led Novak and his team of researchers to search for better ways to represent "what the learner already knows" and to develop the tool of concept mapping in 1972. As a metalearning strategy, concept mapping is largely driven by the Ausubel-Novak-Gowin theory of meaningful learning - a major theory that is designed to help students "learn how to learn" (Wandersee, 1990). It relates directly to such theoretical principles as prior knowledge, subsumption, progressive differentiation, cognitive bridging and integrative reconciliation.

A concept map is a 2-dimensional schematic device for depicting relationship among concepts. It is premised on the belief that a concept does not exist in isolation but is dependent on other concepts for meaning. For example, concepts like primary producers, energy transformation, consumers and decomposers do not exist in isolation. They can be called subordinate concepts that are connect to the superordinate concept of ecosystem. Concepts can also be concrete e.g. kidney, or abstract e.g. osmoregulation. Consequently, it is possible to arrange concepts in a hierarchy on the basis of being abstract and inclusive (superordinate) and being concrete and specific (subordinate).

Students can make concept maps from passages in their biology text or as part of the activities of a biology lesson. In either case, the conventional procedure is to

- note the keywords/concepts, phrases or ideas that are used during the lesson or read in a text;
- arrange the concepts and main ideas in a hierarchy from the most general, most inclusive and abstract (superordinate) to the most speciffic and concrete (subordinate);
- draw circles or ellipses around the concepts;
- connect the concepts (in circles) by means of lines or arrows accompanied by linking words so that each branch of the map can be read from the top down;
- provide examples, if possible, at the terminus of each branch;
- cross link hierarchies or branches of the map where appropri-ate.

An example of a concept map drawn by a student in a recent study conducted by the authors is shown in Figure 1.

A concept map shows the connectedness between and among individual concepts and relies on three fundamental qualities; hierarchical structure, progressive differentiation and integrative reconciliation (Novak, 1990). Progressive differentiation refers to the learning process in which learners differentiate between concepts as they learn more about them. Integrative reconciliation suggests that the learner views relationships between concepts and does not compartmentalize the concepts (Starr & Kracjik, 1990).

## Uses of concept maps in college science

The technique of concept mapping has been recieving considerable attention in the research literature. The focus of these studies typically has gone in two directions. Some work is specifically concerned with exploring the utility value of the tool in teaching and learning. Other research focus closely on how to improve the tool so as to derive maximum benefit from it. Together, these lines of research have generated a substantial body of evidence indicating that concept mapping experience can indeed make college biology "learner friendly". The two strands of research will now be briefly reviewed and implications for college biology teaching drawn.

In order to improve the 'learner friendliness' of biology, concept maps have been put to use in a number of ways - from curriculum conceptualization and development through implementation and evaluation. Many college biology programs as reported by Starr and Kracjik (1990) now evolve from a system where concept maps provide an aid for course conceptualization and development. In this usage, topics to be covered during a given period are mapped to show interconnectedness. This leads to the development of a programme with a good flow of ideas. Combined with textbooks with summary concept maps at the end of sections and chapters, this setup has been shown to improve the appeal of biology to college students (see review by Novak, 1990).

The concept mapping teachnique has also been found to be a useful antidote to rote learning in biology. Research efforts to date confirm that meaningful learning results when the concept mapping heuristic is employed in biology teaching (Schmid & Telaro, 1990). A student learns biology in a meaningful way when he or she is able to integrate new biological concepts into existing cognitive structure. This is demonstrated by the student applying such new knowledge in solving novel tasks or explaining phenomena long after the new concepts were learned. In a study involving college biology students Okebukola (1990) showed that the use of concept mapping facilitated meaningful learning of traditionally difficult concepts in genetics and ecology. It was also shown to be a potent technique for improving the problem-solving abilities of college biology students (Okebukola, 1991a). Further evidence was provided by Cliburn (1986). Working with college students in a course on human anatomy and physiology, he found that students using concept maps during a three-week unit on the skeletal systems showed significantly higher performance on a retention posttest. His results also showed that students using concept maps, gave few verbatim textbook answers to essay questions in another unit of study. In her study with college students in introductory biology, Robertson-Taylor (1985) found concept mapping to facilitate meaningful understanding of biology laboratory work. Furthermore, she found that the thirty students who prepared concept maps prior to each lab session had more favorable attitude regarding biology and biology laboratory studies than the comparison group of students.

In another study, Okebukola and Jegede (1989) showed that anxiety level in college biology classrooms was significantly lowered as a result of students being engaged in concept mapping activities over a 10-week period. The use of concept mapping in evaluation of instruction has also been amply demonstrated. For example, Stewart (1980) found confirmatory evidence that concept mapping is a potent strategy for instructional design and evaluation in college genetics. Concept maps have also served as an important tool for diagnosing students' misconceptions. Since a concept map depicts how a student's knowledge structure is represented, it has been useful for probing the thinking processes of students and identifying misconceptions (Novak, 1991).

Strategies for improving the power of concept maps have also been sought by researchers. Interactive computer programs are now being used to map concepts. As Heinze-Fry (1987) showed, students who use the program significantly outperformed their control group counterparts and learned strategies transferred to new areas of biology. Okebukola (1991b) also demonstrated that college biology students achieved significantly higher mean scores when they map concepts on a cooperative-learning basis rather than individually.

## Concluding thoughts

This paper briefly reviews some of the research that have been conducted in the area of concept mapping to make college biology "learner friendly". Usefulness of concept maps in curriculum conceptualization, development, implementation and evaluation was highlighted. More specifically, the potential of concept maps in making students learn biology concepts meaningfully and without anxiety was discussed.

Concept maps drawn with or without computer assistance, alone or cooperatively, can help students learn meaningfully. As Novak (1991) observes, subject matter ceases to be a mass of definitions to be memorized or problems to be solved by routine plugging in of numbers or symbols into formulas with no idea of why the formula "works". Science, according to him, becomes conceptually transparent, rather than conceptually opaque.

The concept map is not presented in this paper as the wonder device for stamping out all the "evils" of college biology classrooms. Tbe object of the paper is to highlight the potential of the tool with the expectation that teachers and students will be it along with other strategies for making biology teaching and learning fun and friendly.

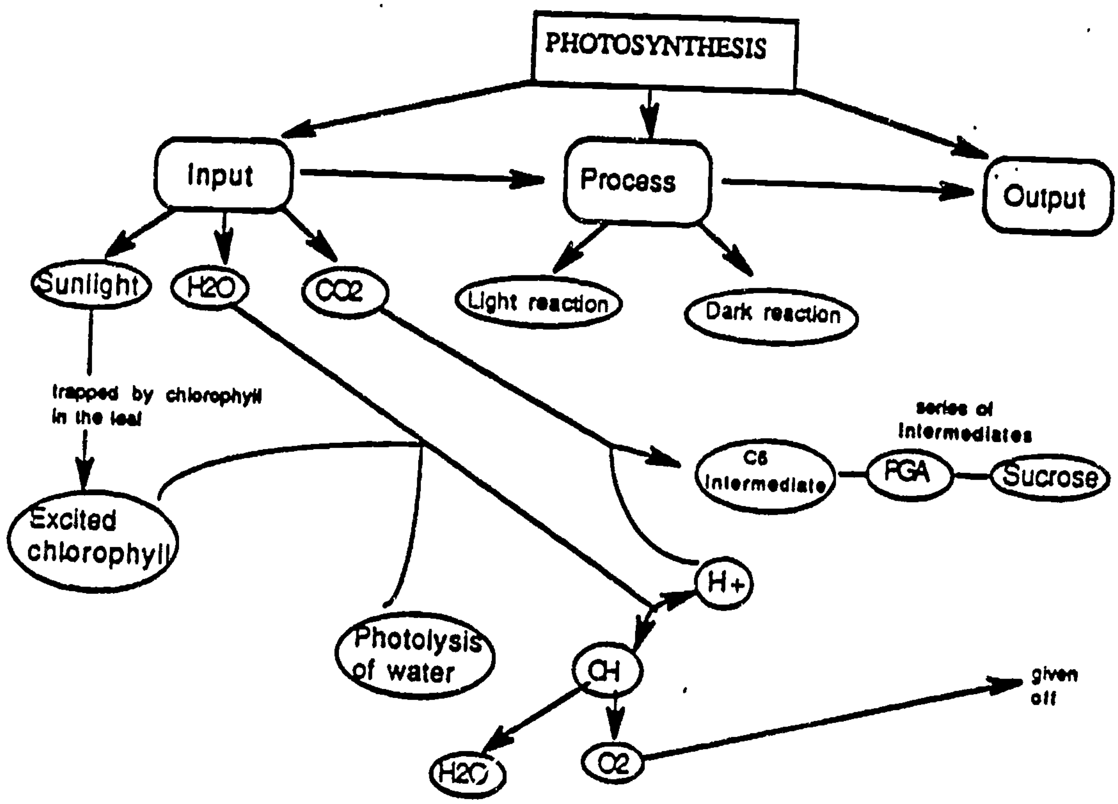


Fig.1 Sample concept map on photosynthesis from one of the experimental groups

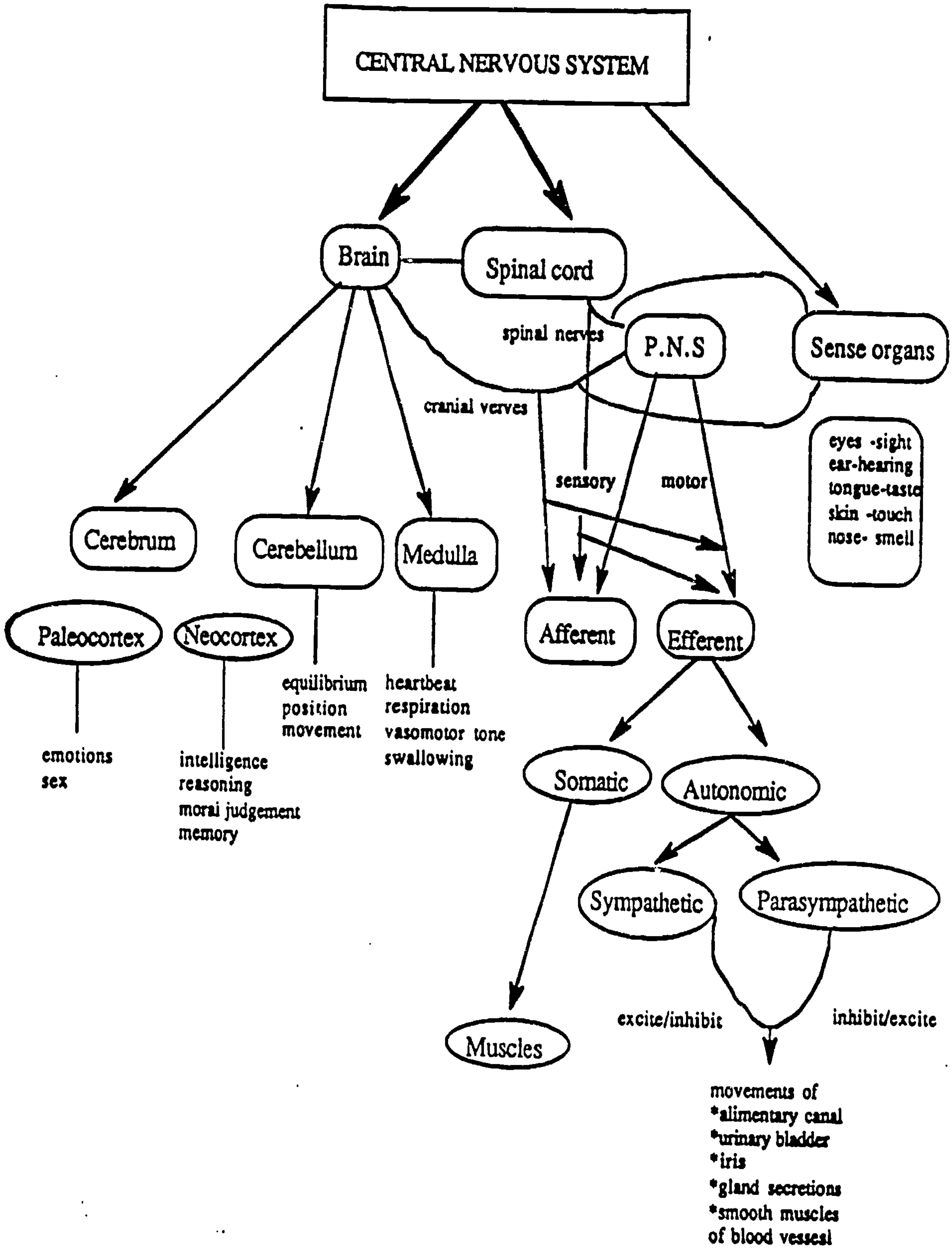


Fig. 2 Sample concept map from one of the experimental groups on nervous coordination in mammals

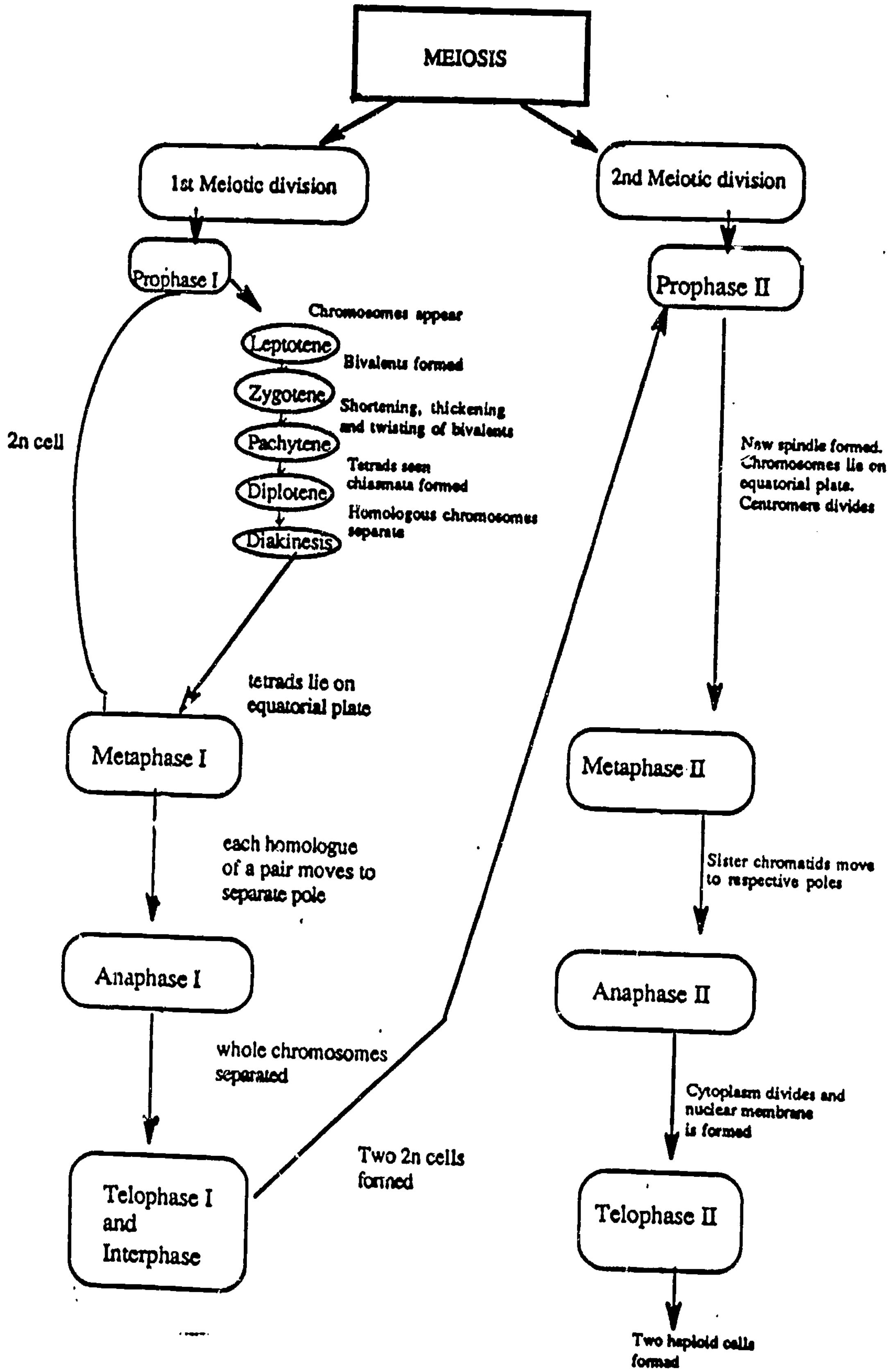


Fig.3. Sample concept map on meiosis drawn by one of the groups

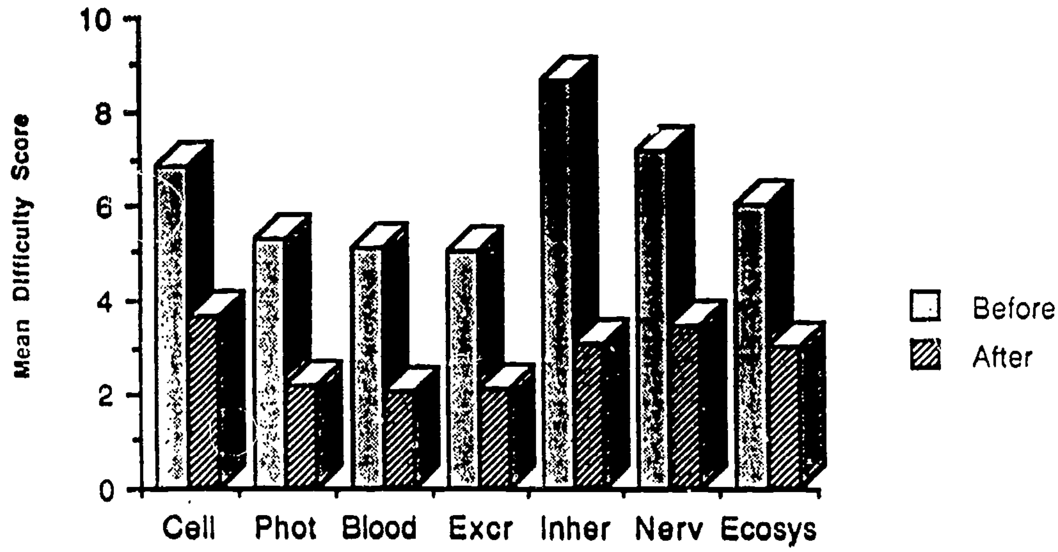


Fig. 4. Histogram of Mean Difficulty Scores Before and After (Concept Mapping Group)

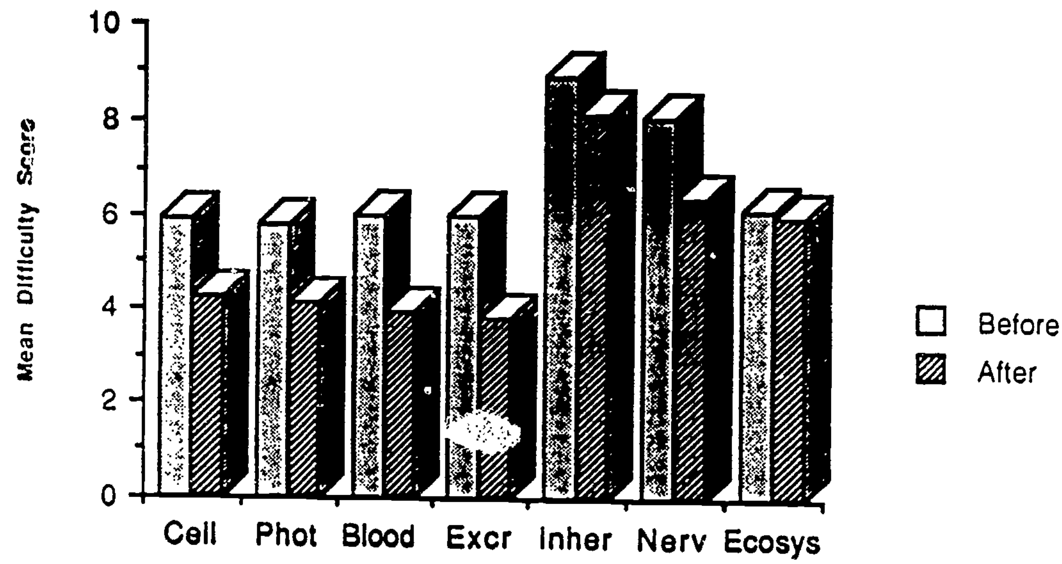


Fig. 5. Histogram of Mean Difficulty Scores Before and After (Comparison Group)

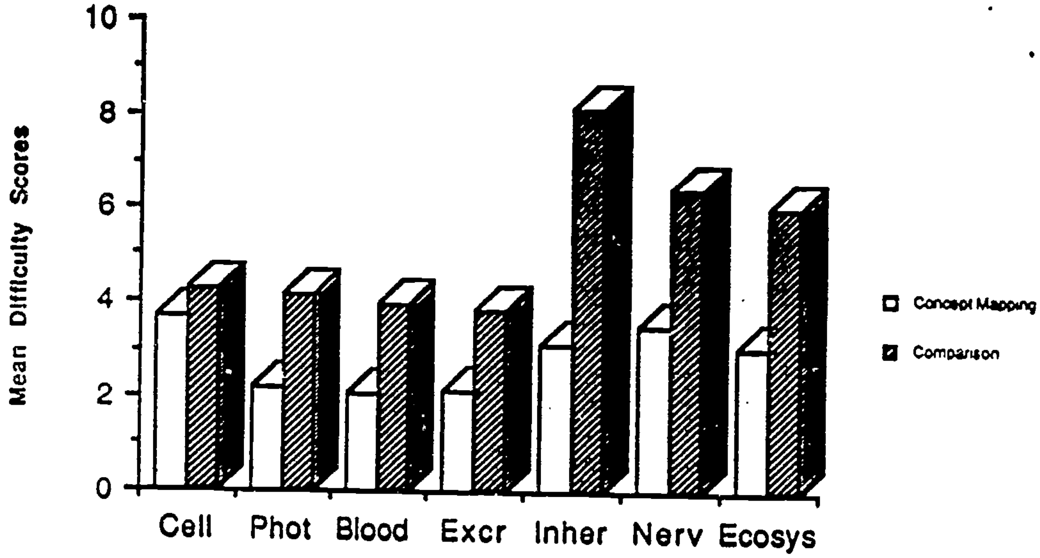


Fig. 6 Histogram of Mean Difficulty Scores of Concept Mapping and Comparison Groups After Treatment

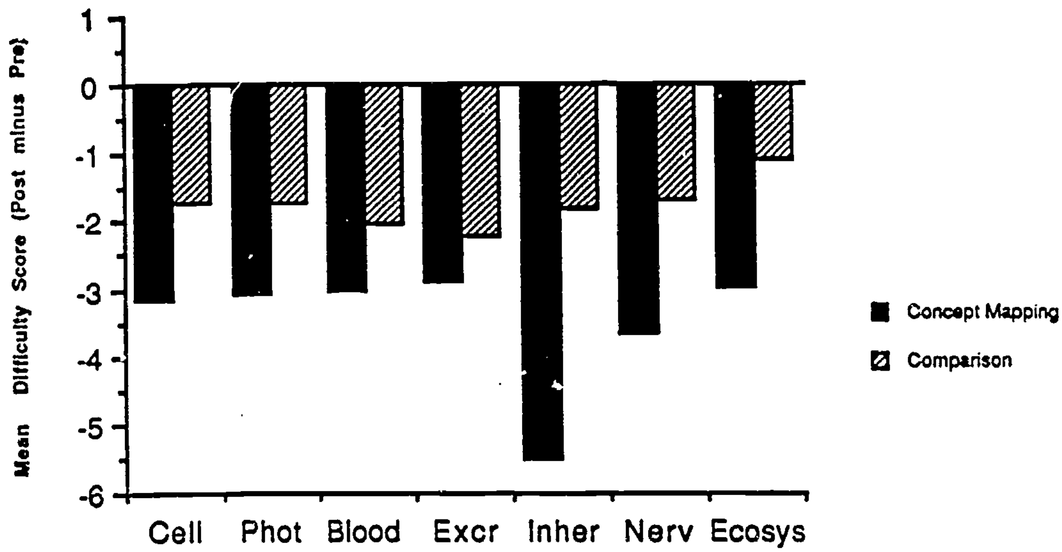


Fig 7. Histogram of Mean Differences between Pre-and Post-treatment difficulty scores