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ISBN 0-315-56109-2

# CONCEPT MAPPING IN STRUCTURAL COMMUNICATIONS

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A Thesis

in

The Department

of

Education

Presented in Partial Fulfillment of the Requirements
for the Degree of Master of Arts at
Concordia University
Montreal, Quebec, Canada

January 1990

## ABSTRACT

Concept mapping is a technique for building a model of a knowledge system. It may be used by an instructional designer in the planning of instruction, or by a student to unlock the meaning in instructional activities and materials. Structural communications is an instructional methodology that allows students to develop a complex answer to a question by selecting items from a response matrix. An elaborate reply is then provided to the student. The development of concept maps is the recommended starting point for the production of structural communications lessons. This study focused on determining how varying student uses of concept mapping affected performance on structural communications lessons for nutrition education. A set of written lessons was produced and a computer programme developed to mediate the instructional system. Thirty second year Quebec college students, evenly divided by sex, were randomly assigned to three experimental conditions. The groups of students that used concept mapping, either by using the designer's concept map or by making their own map for a lesson about protein, demonstrated a better performance than the group that did not use the strategy at all. Although this difference might have resulted from the effects of practise or time spent on task, the study provides value as an opening to further research on the focal question.

**ACKNOWLEDGEMENTS**

Many individuals have contributed support and assistance to the completion of this thesis and I wish to thank everyone and offer my apologies to those left unnamed below. My first formal acknowledgement should go to Dr. P. David Mitchell who helped me in the conceptualization of the project and provided his guidance and expertise during its development and production. Secondly, I wish to thank the students of Champlain Regional College in St. Lambert, Quebec who willingly gave up some of their summer vacation time to be the experimental subjects. Without them, the project could not have been carried out. My colleagues in the biology department of the same college, Sherry Bogert and Peter Woodruff provided encouragement as well as technical assistance that made the task easier. The staff of the Atwater Library Computer Centre helped me to produce the written materials and the printing of this document itself. Finally, but not least, my friends and family who cheered me on and gave me the moral and physical support necessary, especially Dan and Barb, Daniel and Chris, deserve a special thank you.

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# CHAPTER I: INTRODUCTION

The conversation between a teacher and a student has long been recognised as an important aspect of the educational process. The Socratic dialogue is still held as the exemplary teaching model after twenty-three centuries. In Plato's day, a few students could be gathered around a master, each engaging in an individualized conversation until the master was assured that the lesson had been learned by each one. This approach is still maintained in private tutorials, in some graduate study and in many apprenticeship programmes. However, much of modern mass education, following the industrial revolution and, answering the societal needs of that era, has compromised educational dialogue to provide an homogenous educational service to as many students as possible. As we move into the post-industrial age, the need for this type of education is diminished and advances in electronic computing technology make it possible to provide individualized services to more people. It is desirable therefore, to begin to develop interactive software which simulates an educational dialogue for a wide variety of learners.

One possible way to simulate an educational dialogue is through the use of a structural communications format. Structural communications is an instructional approach which provides a complex interactive environment (Egan, 1976).

Originally designed for the print medium, it provides an interesting approach for student response and author reply using a limited or structured vocabulary. Structural communications lessons are constructed using a concept map as a model of the subject matter. Each unit subsequently provides text material about the subject matter followed by an investigation or problem which demands the student's active participation in the lesson. The student generates an answer to this question by selecting some items from a collection of twenty to twenty-four possible items provided by the author in a response matrix. The student is referred to a reply paragraph which is appropriate for the particular selection.

Concept mapping is a technique of illustrating the relationships between the concepts which are the units of a subject matter. As well it may be used to assist the student to link new concepts with those previously acquired. Concept mapping is closely allied with concept analysis and may be thought of a way of visually setting out this process. Pattern notes is another term sometimes applied to a variation of this technique. Concept mapping has been used extensively to help students extract meaning from their school work (Novak and Gowin, 1984). It may also be used as an instructional design tool to focus the attention of producers of educational materials on the key points in a subject matter (Rowntree, 1981).

This project was designed to study the varied student uses of concept mapping while following a series of structural communications lessons introducing nutritional principles to college students. Each of the lessons was developed from a concept map drawn for that particular section of the subject matter. A variation from the print style of structural communications was provided by a computer programme which was written to analyze the student's selection and provide a complex reply built up from a series of phrases and sentences. The performance of three groups of students was compared: one group drawing their own map, a second group using the author's map and the third using no map.

Nutrition was chosen as the subject matter for several reasons; not the least is the author's personal interest and knowledge. As well, college students seem to know very little about this topic in spite of their voracious appetites. Thus, prior knowledge should not provide too much interference in the study, while students potentially could benefit from the time spent on the experiment.

## CHAPTER II: LITERATURE REVIEW AND BACKGROUND THEORY

### Model Instructional System

Underlying this project is the belief that instruction is a planned intervention into the learning process. This intervention is usually made by one individual for another. As well, fundamental to educational technology is the view that instructional events or activities occur as part of a system. Ackoff (1971) defines a system as "an entity which is composed of at least two elements and a relation that holds between each of its elements and at least one other element in the set." Therefore, as part of any educational technology approach to instruction, one must identify the elements in an instructional system and the relationships among them. Figure 1 represents a model of an instructional system. (See next page.)

In this figure, two key elements are the instructor and the learner. The instructor has an instructional intention on which the intervention into the learning process is based. This intention may be best described as a model of the intended outcome and may be developed as the goals, aims and/or the objectives of the system. The instructor also has a second model, that of the learner's entry level capabilities. The learner enters the system with prior knowledge and experience, as well as an intention or

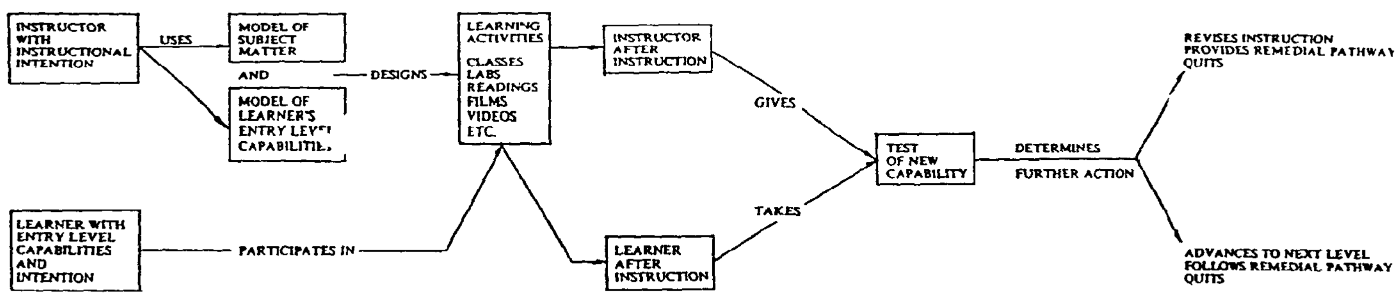


FIGURE 1: A Simplified Model of an Instructional System

objective. The instructor's model of the student can be developed through diagnostic testing or from a history of the learner's experience. There is usually a discrepancy between these two models which dictates the need for instruction.

The instructor then arranges for a variety of possible learning activities, such as classes, readings, discussions, laboratory exercises, internships, films, videos, etc.. The learner participates in the system through these learning activities and develops new capabilities in the process. The learner may be considered to be building a personal model of the subject matter at this time. Following these activities a comparison is made between the learner's newly acquired characteristics or model and the instructor's model of the outcome. Usually, this is considered as a test which is based on the model of intended objectives and should measure the degree to which they have been achieved. The results or score of the test provides feedback, both to the instructor and to the learner, and should serve as the basis for further action. A remedial pathway may be indicated to correct mistakes or misconceptions. The learner may graduate or go to a higher level system. The learner may also quit the system completely and go in some very different direction. Revision of the learning activities by the instructor may also be appropriate before exposing another student to the system.

This model is removed from its environment and consequently does not show all of the factors which usually impinge on such a system. This simplification has been made in order to focus on the key elements and processes involved in instruction. The model may be applied to several situations from high level training situations to individualized or self-directed lessons.

Applying the model to an educational dialogue situation, many rounds of the system may be observed and there is a dynamic modelling process occurring. The student builds and refines a model of the subject matter and the instructor's model of student capabilities gradually changes to be closer to the model of the intended outcome. Learning activities continue until the two models are quite congruent. In the Socratic dialogue situations, the master makes the judgement necessary to conclude the dialogue according to a rather narrow standard. In mass education, the congruence is judged by very broad standards.

This view of an instructional system has been developed from several sources of cybernetic literature and was developed through an educational cybernetics course as described by Boyd (1981). Neil (1969) proposed a similar model of a learning system when he also advocated applying systems theory to research in educational technology. The model proposed in this thesis is also consistent with the cybernetic approach in the conversation theory of Gordon Pask (1976, 1984). Johnson and Hartley (1984) summarise Pask's theory and explain how two individuals come to agree on shared concepts through repeated discussion. Likewise, the model instructional system (Figure 1) is compatible with the educational philosophy espoused by Gowin (1981). Coldeway (1987) argues for the use of this type of approach as a basis for instructional system design for distance education courses. He sets out the same characteristics described above and elaborates on the application of instructional system modelling to the design, production, implementation, and evaluation phases of curriculum and course development.

**Modelling Knowledge**

Mitchell (1982) takes the view that knowledge may be considered as a system. That is to say that for any particular subject matter there are concepts, procedures, criteria etc. which are organized such that meaningful relationships can be established among them. Thus, Mitchell advocates the building of models, that indicate the relationships among these various parts of the knowledge structure of a subject, as a part of the instructional design process. This, he points out in a later article (1988) is more than the elaboration of the behavioural objectives for a lesson or course. The modelling process should precede objective writing and they should flow from it. In the same article, Mitchell also presents the possible view of learning as a conceptual modelling process, with the learner building his own representation of the subject matter as he participates in learning activities. Evaluation of learning can then be done by comparing the student's representation of a subject with that of the instructor. This comparison should then be the basis for feedback to both parties. Another benefit of subject matter modelling described by Mitchell (1982) is the establishment of multiple routes through any knowledge structure and the consequent variety of outcomes. This he sees as invaluable in the design of truly individualized instruction. Good (1987) lends further support to the use of modelling of subject matters by students, and instructors in applying artificial intelligence to instructional systems for science education.

**Concept Mapping**

There are a variety of tools available for assisting an instructor in developing the models necessary for an instructional system. Achievement tests, diagnostic tests, measures of literacy, and the school history of the learner, are part of the information needed to build models of the learner's entry level capabilities. DACUM, an acronym for Designing a Curriculum, is a modelling method for developing course and programme objectives. This is a brainstorming approach where several subject matter experts are gathered together. They suggest the requisite knowledge and/or skills to be derived from the instruction. Each suggestion is written on a large file card and it in turn is attached to a large clear surface such as a wall. This provides a basis for the discussion that follows. The cards may be arranged and re-arranged easily to build a model of the desired outcomes. Although this method has most often been used for elaboration of the objectives for skills training courses, it is actually a useful approach for all types of group problem solving situations. Details of how to conduct or operate a DACUM session are described by Romiszowski (1981) and in a series of pamphlets by B.J. Mitchell (1983). Holden (1983) provides another source of information about the DACUM method and a rationale for its use.

Concept mapping is another tool that can be applied to building courses for cognitive knowledge skills. A concept map is a diagram showing the words that represent the concepts in a particular subject matter. In addition, the relationships among the concepts are expressed. It may be considered as a visual representation of a subject matter and may also be considered as a model of the subject matter in the sense advocated above by P.D. Mitchell.

Novak and Gowin (1984) recommend this technique as a learning activity to help the student develop links in a cognitive framework. For them, a concept is a regularity in the sensory experience which can be named or given a symbol. Concepts may be concrete such as a chair or a table or abstract such as justice and peace. Their approach follows the educational psychology of Ausubel (1968) who points out the importance of relating new concepts to those already held by the learner. Diagramming a subject area should help the student make better connections with previously learned material. Although Novak and Gowin also have recommended the use of concept mapping in instructional design, this use is more strongly suggested by Rowntree (1981) as a means of establishing what is to be learned and the appropriate sequence for instructional events in the design of instruction. Jonassen et al. (1988) also presents a strong case for the use concept mapping in the design of expert systems for computer assisted instruction.

There is a considerable body of evidence that further demonstrates an improved student performance through the use of concept mapping technique in a wide variety of courses and with a wide variety of age groups. Arnaudin, et al., (1984) report the results of several investigations into the use of concept mapping in college biology courses. Comparing mappers with non-mappers, they found that the students using concept mapping achieve significantly higher course grades than those who do not use the technique ($p < 0.05$). Articles by Ault, (1985), Moreira, (1985), Novak, (1979, 1980, 1981), Novak and Gowin, (1984) and Smith, (1987) provide further references to studies demonstrating improved student performance through the use of concept mapping.

**Structural Communications**

Structural communications is an instructional approach, which conforms to the model of an instructional system as presented above, and is developed from a concept map. This technique was invented in the 1960s by Bennett and Hodgson as a means of providing a higher level dialogue, between an author of instructional materials and their user, than the then popular programmed instruction could offer. The philosophy underlying this approach is summarized in Hodgson (1974). Egan became involved in the production of structural communications lessons and published a book in 1976 that offers a concise background and history of its development. This book also contains several examples of structural communications lessons and a variety of uses for them. There is also a chapter dedicated to instructions on how to develop a structural communications unit.

A structural communication lesson consists of six parts. It opens with an Intention which locates the lesson in a curriculum or provides a rationale for its study. Objectives may be provided here and advance organizers may be added to assist the learner in finding a context for the lesson. A Presentation follows as a description of the course content on which the lesson is focused. This section is not unlike that of a typical textbook, although other types of presentations may be used in place of a written one. A laboratory dissection or experiment may be considered as a presentation. Likewise, a slide tape programme, a video tape or a film may be used. Howard (1981) used film to provide this portion of a structural communications lesson for training farmers. Madsen (1982) used a videotape presentation in a structural communications unit for military training.

The third section presents challenges or problems which involve students in an interaction with the subject matter and this is known as the Investigation. After thinking about a solution to the given problem, students use a Response Matrix to compose an answer to the problem. Here is one of the most interesting aspects of structural communications. A response matrix consists of twenty to thirty items relevant to the problems posed in the Investigation. From this matrix, a student selects and arranges those items that provide an appropriate response. The student's selection is analyzed and a referral made to the appropriate Discussion item. The latter is a reply by the author to the student response which comments on discrepancies, and points out misconceptions or errors implicit in the particular choice of matrix items. Finally, the Viewpoints section may provide alternative ideas on the subject matter, and further explanations, while making links with subsequent lessons.

Structural communications provides many of the elements of a conversation. Its strengths lie in the possible composition of a fairly complex response to a problem and the provision of feedback to the user that can point out errors and misconceptions. In the original paper bound format, the provision of this feedback is quite ungainly. In order to find the proper discussion element, the user must analyze his own response using a complicated series of formulae showing what was included or omitted. It seems that this part of the process is very unsatisfactory and has probably been the major reason that structural communications did not become popular as an instructional format.

Baath (1979) describes this approach to instruction and points out the possible value of structural communications as a model for correspondence education. Emmott (1984) tested the use of structural communications as a design method for computer aided instruction. He found that subjects using the computer mediated structural communications version of his lessons achieved a higher level of understanding than the subjects using other formats. Emmott also found the computer approach more efficient in terms of the time required to reach this level of understanding. Romiszowski (1986, 1988) also presents structural communications as a possible basis for the development of computer aided learning systems. He suggests the use of the computer as a mediator between the student's response and the discussion items in order to make structural communications a more effective and popular instructional technique.

## CHAPTER III: METHODOLOGY

### Focal Question

Based on the evidence previously cited, concept mapping technique may be used both as an instructional design tool, to improve the quality of educational materials, and as a learning tool to improve student performance. The project focused therefore on investigating the question:

> Do students who make their own concept map for a subject matter demonstrate a superior performance to those who have access to the designer's concept map, and to those who do not use any map while interacting with a structural communications lesson?

Since the materials needed for the study did not previously exist, completion of the project required an extensive design and production phase prior to carrying out the actual experimentation. Thus the project can be seen to comprise three different parts: design, production, and experimentation phases.

**Design Phase**

Basic nutrition education was chosen as a subject matter for the lessons involved. It was also decided to aim these lessons at college students. The author is currently a biology teacher at a community college and has taught this subject matter as part of a general introductory course in biology over several years. In addition a study by Chery, et al. (1987) indicated that while nutritional awareness has increased in the general population, actual knowledge of nutritional principles remains low in Canadian University students. Since there appear to be links between nutritional status and several disease situations, for example high cholesterol with heart attacks and strokes, increasing nutritional knowledge in college students may contribute to longer, healthier and happier lives. Nutritional habits are also idiosyncratic and it seems an appropriate area for the beginnings of production of self instructional materials.

The subject matter content for the units was based on the design of a fifteen hour minicourse in nutrition for these students. This content was elaborated by generating a series of concept maps by following a modified DACUM approach. In this method, the key words standing for concepts are written on small slips of paper and stuck with removable glue to a larger sheet of paper mounted on a wall or table top. This allows the slips to be moved and re-ordered several times until a suitable map develops. In a complex subject matter, the need for several lessons appears early on and the links between these units can be made. The sequence of the lessons also becomes more obvious as the process continues. The final concept maps for each unit can then be copied neatly onto a single sheet of paper. Two examples of the maps appear in Appendix One. From the completed maps, a set of objectives for the mini course was established. The combination of the objectives and the concept maps are considered as the instructor's model of the subject matter in the instructional system discussed previously and seen in Figure 1. At this point work began on the materials production phase.

**Materials Production**

The minicourse was divided into subsections or modules. Three of these, Introduction to the Digestive System, The Fats, and The Proteins were chosen as materials for this particular study. The print sections of the structural communications lessons were written up. Each consisted of an Intention, a Presentation and an Investigation. These partial lessons were distributed to college students in the Fall semester of 1988 as text materials for a unit of a course that the author was then teaching. This provided an initial screening of the materials. Students completed the questions posed in each Investigation and returned these to the instructor. Perusal of these written answers provided an informal accumulation of the types of misconceptions and errors made by typical students. These were subsequently incorporated into the response matrices when the modules were converted to the structural communications format. A Viewpoint was also added to complete each module.

A fourth module was developed to introduce students to the technique of concept mapping. This was based in part on the suggestions of Gowin and Novak (1984) for introducing concept mapping to college students. This module provides examples of concept maps for students and also refers students back to the digestive system module to investigate the system's functions using a concept map provided by the author. (Appendix Two contains a copy of these modules as arranged for test group C, the experimental group.)

In the original version of structural communications, the student's reply to the investigation is analyzed by a chart showing inclusions and omissions. The student is asked to determine whether the items selected fit into various categories and is then referred to one of a number of paragraphs to see the author's reply to this selection.

This aspect of structural communications is difficult to manage from the author's perspective and more trying to use from a student's perspective. Consequently, the analysis of the student's response was replaced by a computer programme.

Using the Hypercard authoring environment and a Macintosh computer a system was produced for accepting a student input and then developing a reply to it. The student uses the print materials to obtain the information and works out an answer to the investigation. This answer is then entered into a grid which appears on the computer screen. The script for Hypercard writes each of the student's choices on the screen and the student can make alterations to the choices fairly easily before processing the answer. Initially, an inventory of the student's input items is developed and errors of both omission and inclusion are tabulated by comparison to the instructor's model. The programme then compares the student's input with the instructor's model of the answer. If there is a match, the programme rapidly returns a simple response that the student is correct and directs him to the next section. Otherwise it follows an algorithm which looks for the inclusion of the right items, inclusion of wrong items and omission of right items. In some cases, sequence is also considered.

The programme then assembles an extensive reply by following another algorithm. This draws on a series of sentences and phrases written into the programme to pull out the ones appropriate to the inventory. As the student's answer deviates further from the instructor's model, these comments provide extensive explanations about the differences. The student is given an opportunity to compare his selection with the instructor's model answer. A grading scheme is written into the programme to provide the score used to evaluate student performance. This score may be considered to be an index of the coherence between the student's model answer and that of the instructor. For the purpose of this project the grading scheme is neither emphasized nor explained to the user. Printed samples of the computer screens seen by the student users are available in Appendix Three.

**Experimental Design**

In order to compare student performances using concept mapping, it was arbitrarily decided to use the Protein Module as the test item. The sequencing of the four modules was varied so that all students received exposure to the nutritional information and concept mapping techniques.

All students were introduced to the structural communications format through the Introductory Module, which also introduced them to the structure and function of the digestive system. The experimental group, labelled as Group C followed the sequence provided in the sample study guide included in Appendix Two of this text. These students learned about concept mapping, practised the technique by mapping the presentation section of the Fat Module and then made their own map for the Protein Module before completing its investigation. Group B students were also introduced to the technique but utilised the designer's map (Figure 2, Appendix One) while completing the Protein Module. After the testing, these students were given the opportunity to make their own concept map for the Fat Module. The control group students (Group A) moved directly to the Protein Module following their Introductory Module. They did not use the concept mapping technique. However, so that they could become familiar with this as a potential learning aid, they were introduced to the technique, and completed their test session applying concept mapping to the Fat Module. The experimental design is diagrammed in Figure 2.

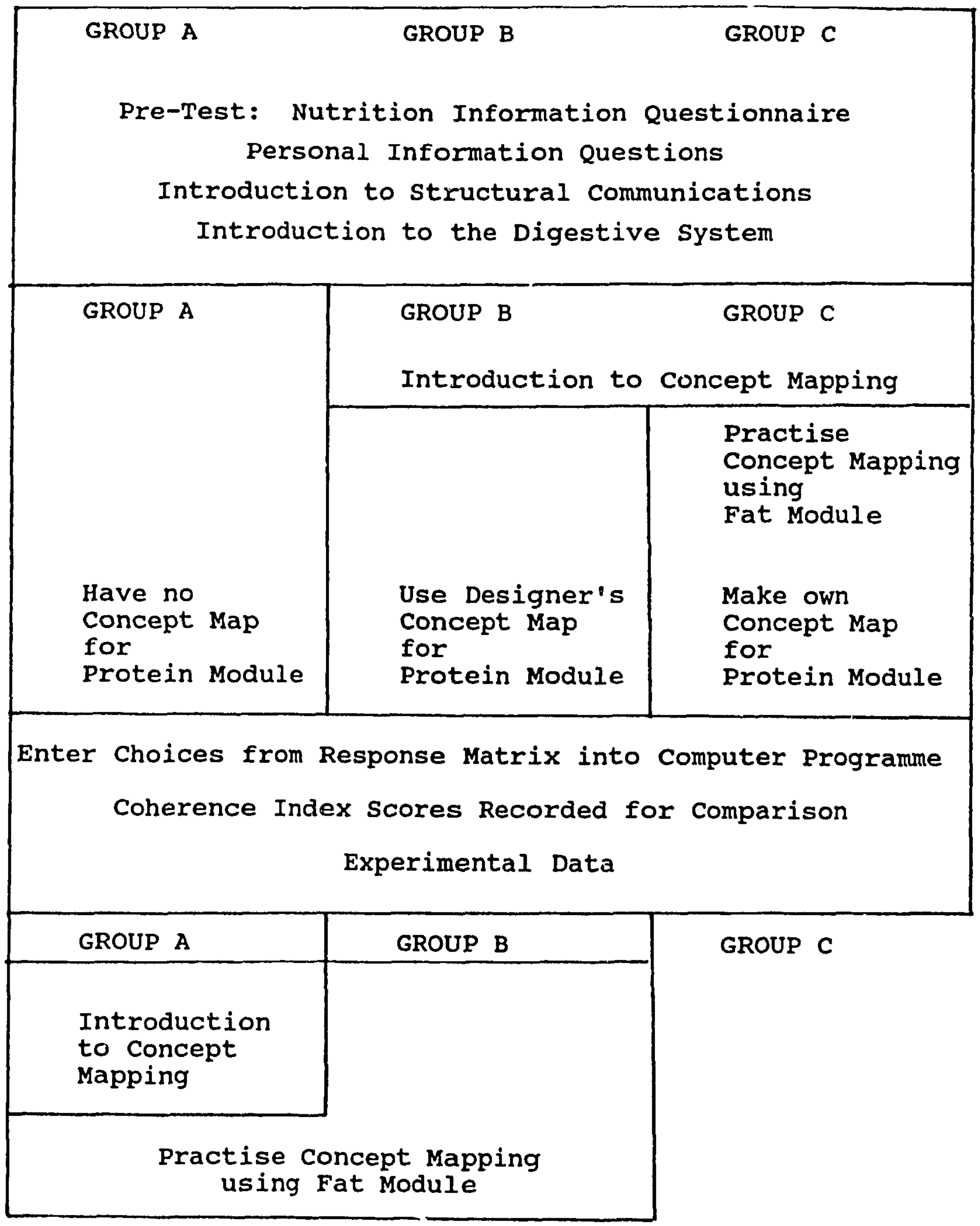


Figure 2: Diagram of Experimental Design

**Statement of the Hypotheses**

The experimental design was developed to provide data to the focal question of the study:

> Do students who make their own concept map for a subject matter demonstrate a superior performance to those who have access to the designer's concept map, and to those who do not use any map while interacting with a structural communications lesson?

The author predicted that:

1. The groups of students who employ the recommended concept mapping technique while participating in the Protein Module will obtain better group average coherence scores than those who do not.

2. Further, the group of students who become involved in the lesson by constructing their own concept maps will attain the highest group average scores.

3. Those students who have access to the designer's concept map while working with the lesson will have intermediate group average scores.

4. That group of students who do not use concept mapping technique during their testing will have the lowest group average scores.

# CHAPTER IV: EXPERIMENTAL PROCEDURE

Fifty-four student subjects were recruited from the group of returning students registering in June, 1989 for the fall semester at Champlain Regional College in St. Lambert, Quebec. Most of these students were consequently entering their third semester in a four semester Quebec college system. Of these recruits only thirty-four arrived for their scheduled testing sessions. Three of this group then failed to follow instructions and were consequently dropped from the study. One other student, older than most and entering his fifth semester was also dropped to create three testing groups of ten students each. The thirty students then constituted a group of teen aged subjects with an average age of 17.8 years. The total population was by chance evenly divided by sex.

## Site of Experiment and Subject Assignment

The author was given the use of a Macintosh computer laboratory to accomplish this project as the summer session at Champlain Regional College was drawing to a close at the end of June 1989. This laboratory contained nine computer stations networked to a central computer and hard disc unit. Testing sessions of three hours each were arranged for mornings and afternoons. Students had selected a day and time of their convenience as they were recruited. Only six days of sessions were utilised to accommodate the students. Initially, sessions were assigned to one of the three experimental conditions, but later different situations were presented to students within a session to balance the group numbers. Students unknowingly chose the situation by their pick of stations in the room. This is assumed to have had a randomizing effect for subject assignment.

**Experimental Protocol**

Each student was provided a work space containing a computer, three ring binder and pencil. Each binder contained a pre-test and a study guide arranged in the appropriate format for one of the three groups. Each student was assigned an identifying code number which indicated the testing condition and provided for the confidentiality of the data.

The student began the session by completing a pre-test. This was a Nutrition Information Questionnaire provided by the Department of Family Studies of the University of Guelph in Ontario. This is the same questionnaire used in the study cited above by Chery et al.. It consists of sixty-nine statements about nutrition which are answered as true, false or don't know. The items cover topics such as health foods, environmental factors, weight loss or gain, nutrient requirements and function, digestion and metabolism. The questionnaire was retyped and formatted to allow correction and item analysis using an optical scanner connected to a computer and printer. Although the questions about personal background were modified slightly, no changes were made to the original questionnaire's statements. It took students fifteen to twenty minutes to complete this test.

All students were then directed to begin reading their study guides and worked on the first module, Introduction to the Digestive System. The author was available to provide some guidance about entering their selections from the first matrix into the computer. Although a few students required extra briefing about the use of the mouse and the keyboard because of limited previous experience using computers, all quickly developed their skill at using it and any initial reluctance dissipated rapidly as they proceeded through the first module.

At the completion of the module, the student read the reply from the programme and the author recorded the score for the module manually onto a record sheet. This score is an index of the coherence of the student's response to the instructor's model answer. A perfect coherence is given 100 points. Errors of omission and errors of inclusion are penalized by the deduction of points according to an algorithm written into the computer programme. There are some neutral items that do not cause a penalty, although the student is told why they are not considered to be necessary to the response. The score recorded was the one generated by the programme as described previously. Students were not informed of the meaning of this score during the testing session and it was not used to provide feedback to them. The same protocol was repeated for each of the subsequent three modules. Most students spent almost three hours completing the tasks. Since speed was not a factor in the experiment no timing was done and no one was rushed to complete the work. Each student received a package of nutritionally sound snack foods and two dollars and fifty cents to help defray the cost of their transportation to the college for the session. The material used by the student were deposited into envelopes so that text materials could be returned to the students at a later date.

## CHAPTER V: DATA AND RESULTS

The experimental phase of the project was carried out in nine testing sessions spread over six working days. Each session lasted three hours and none of the students required more than the allotted time. Student participation was supervised by the experimenter who remained in the room at all times. Advice was provided to individual students about the input of their responses to the computer programme. No advice was given about content or concept mapping techniques. Data were collected about the students preliminary knowledge, as well as age and college year through a computer corrected pretest. The scores achieved on each module were collected as each student completed it, and those of the protein module were used as the comparative basis for this study. These data and the analysis of it are reported below.

### Pretest of Nutritional Knowledge

The Nutrition Information Questionnaire consisted of 69 statements of nutritional facts or fictions which were to be answered as true, false or don't know. This is the same test as used by Chery *et al*. in 1984 and is not included with the documentation of this study in order to keep it from general circulation. Grading of the questionnaire followed the same pattern used by Chery: the percentage of the correct answers is regarded as the level of knowledge; the percentage of the wrong answers is regarded as a measure of the prevalence of misconceptions and the percentage of don't know choices is taken as a measure of uncertainty.

Table One is a summary of the pretest data for the thirty subjects participating in this study as compared with the data reported by Chery et al., (1984). They had found disappointingly low levels of knowledge and this administration of the test produced even lower scores. A t-test applied to this comparison of scores of knowledge level indicates a significant difference ($p < 0.01$) exists between the two groups.

A comparison of the average levels of knowledge of the subjects as sorted into the three test groups is shown in Table Two. Interestingly, the three groups appear to differ in their knowledge of nutrition with a decrease across the three treatment conditions. However, a single factor analysis of variance (ANOVA) performed on this data revealed no significant differences across the groups.

Table One
Nutrition Information Questionnaire-Group Means Comparison

| Assessment Category | Champlain Experimental Group 1989 | Chery's Students 1984 |
|---|---|---|
| Knowledge Level | | |
| % Correct responses | 44.7* | 56.6* |
| Standard Deviation | 12.2 | 10.6 |
| Prevalence of Misconceptions | | |
| % Incorrect responses | 29.5 | 25.2 |
| Uncertainty | | |
| % Don't know responses | 25.8 | 18.4 |
| % Total | 100.0 | 100.2 |
| Number of Subjects | 30 | 272 |

* ($t = 5.21$, $p < 0.01$)

Table Two
Comparison of Levels of Knowledge Across Treatment Groups

| | Group A | Group B | Group C |
|---|---|---|---|
| Highest Score | 70 | 64 | 51 |
| Lowest Score | 25 | 36 | 9 |
| Group Mean | 49.9 | 45.7 | 38.5 |
| Standard Deviation | 13.0 | 9.4 | 12.0 |
| Number of Subjects | 10 | 10 | 10 |

**Protein Module Performance**

Built into the computer analysis programme is a scoring formula that determines the degree of correspondence between the student's input and the model answer provided to the programme by the author.

Table Three contains a summary of the data accumulated by recording the score of each user of the programme as they completed the Protein Module. A single factor ANOVA indicated the presence of significant differences at the $p < 0.01$ level. This is summarized in Table Four. A graphical comparison of the data appears in Figure 3.

Subsequent ANOVA single degree of freedom comparisons were made to test the experimental hypotheses and isolate the origin of the variance. These are summarized in Table Five. The planned comparison of Group A (no mapping - control) scores with the combined treatment groups (B and C) supports the first hypothesis that the utilization of concept mapping produces an improved performance ($p < 0.01$). A *post hoc* ANOVA comparison of Groups A and C, also reveals a significant difference between the students using no maps and those making their own maps ($p < 0.01$). This difference is further supported using Scheffe tests. The comparison of

Table Three
Comparison of Levels of Protein Module Scores Across Treatment Groups

| | Group A No Map | Group B Design Map | Group C Made Map |
|---|---|---|---|
| Highest Score | 84 | 88 | 100 |
| Lowest Score | 40 | 60 | 60 |
| Group Mean | 63.8 | 75.2 | 81.6 |
| Standard Deviation | 11.9 | 10.1 | 11.4 |
| Number of Subjects | 10 | 10 | 10 |

Table Four
ANOVA Summary

| Source | Sum of Squares | DF | Mean Square | F Ratio |
|---|---|---|---|---|
| Between Groups | 1625.9 | 2 | 812.9 | 6.56* |
| Within Groups | 3347.6 | 27 | 124.0 | |
| Total | 4973.5 | 29 | | |

* (p < 0.01)

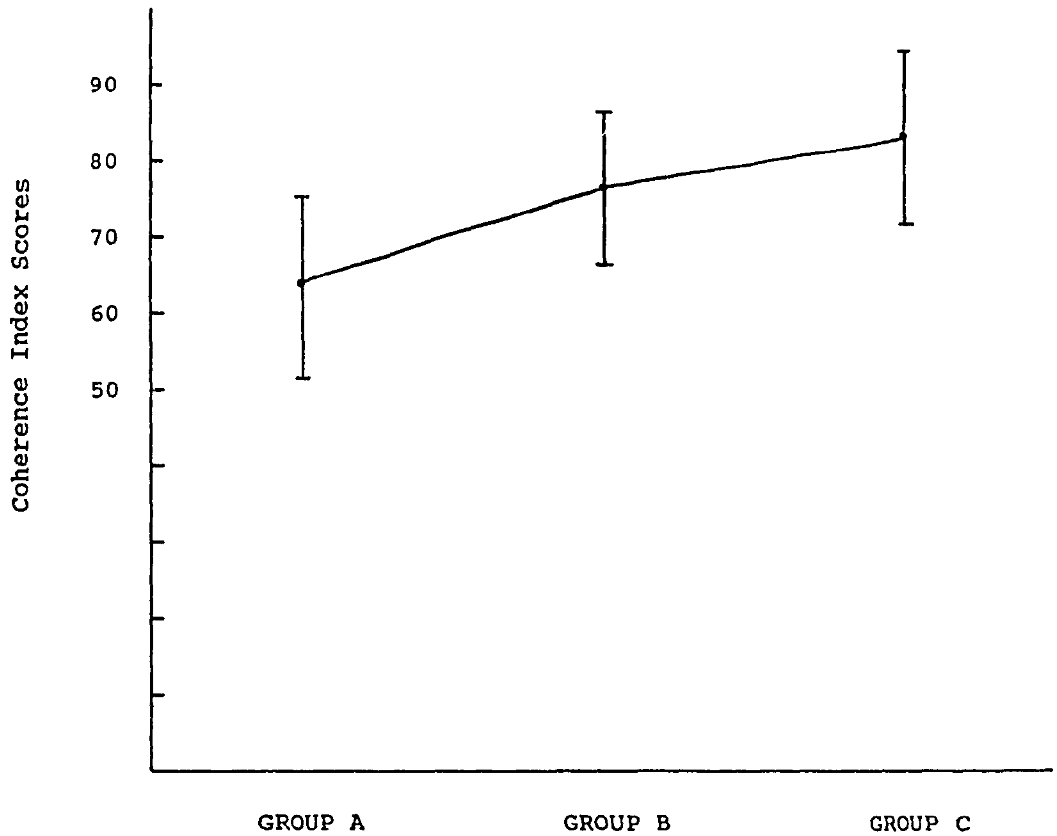


Figure 3: Mean Protein Module Coherence Index Scores
Brackets indicate ±1 standard deviation

Groups A (no map) and B (designer's map) shows a significant difference at the $p < 0.05$ level.

Although Group C students who made their own map for the Protein Module showed the best group average, statistical testing does not reveal a significant difference between the mean for this group and that for Group B (designer's map). As might be expected, an analysis of trend applied to the slope of the graph in Figure 3 produced results similar to the comparison of Groups A and C.

Table Five
Comparisons of Protein Module Scores Between Treatment Groups

| | | Group A No Map | Group B Design Map | Group C Made Map |
|---|---|---|---|---|
| Group Mean | | 63.8 | 75.2 | 81.6 |
| Number of Subjects | | 10 | 10 | 10 |

| Comparison | Sum of Squares | DF | Mean Square | F Ratio |
|---|---|---|---|---|
| Planned Comparisons | | | | |
| A x (B + C) | 1421.1 | 1 | 1421.1 | 11.46* |
| B x C | 204.8 | 1 | 204.8 | 1.65 |
| Post Hoc Comparisons | | | | |
| A x B | 649.8 | 1 | 649.8 | 5.24** |
| A x C | 1584.2 | 1 | 1584.2 | 12.78*S |
| Residual | 3347.6 | 27 | 123.9 | |

* $p < 0.01$
*S $p$ (F-Scheffe) $< 0.01$
** $p < 0.05$

# CHAPTER VI: GENERAL DISCUSSION AND CONCLUSIONS

The experimental phase of the project revealed interesting results about the relatively low level of student knowledge of nutrition. The testing of the concept mapping theory produced evidence to support the hypothesis that use of the technique is beneficial to students. As well, the experimental phase provided a substantial test of the materials which had been designed and produced in other parts of the project.

## Pre-test of Nutritional Knowledge

The purpose of using this test was to establish that three test groups shared an equal knowledge of the subject matter and were typical of Canadian college students in this regard. The test served its first purpose in showing that there were no significant differences across the treatment groups despite the differences in group mean scores. In the second instance, the scores are well below the level of knowledge reported by Chery et al. (1987). These low scores provide evidence to support the development of nutrition education materials aimed at Quebec youth.

**Protein Module Performance**

The data accumulated from this key aspect of the study supports the experimental hypothesis of a differential performance depending on the use of concept mapping technique. The first hypothesis that students who employ the concept mapping technique will achieve better scores than those who do not is supported by the significant difference in the comparison of Group A (no maps made) with Group B (use designer's map) and Group C (made own map). However, although the three group averages are arranged as predicted in the hypotheses, Group C did not demonstrate a statistically different performance from Group B. Group B, though, does show an improved performance over Group A, the non-mapping group. There is also a significantly different and improved performance between the students making their own maps and those who did not use the strategy at all.

There are several sources of error which may have biased the results of the experimental phase of the project. No data was recorded about the student's verbal ability in the form of reading test scores or previous college course grades. It may be that there is a distortion based on an interaction of this factor with the test conditions. Some students may visualize information and/or make mental maps which could distort the results. Also, perhaps some students absorb information and make links with prior knowledge more readily than others. No measure of student motivation was taken. Student motivation to complete the tasks assigned seemed to be high as they all appeared to work diligently at the project. While it was hoped that the effects of these factors would be reduced by random assignment of subjects, there was a relatively small number of subjects per group, and consequently, some bias may have occurred.

Another possible distorting factor concerns an element of practise. Students in Group C worked on the test module as their fourth activity and made two concept maps prior to being tested. Group A students passed through the protein module as their second activity. Again in a more comprehensive study with a larger number of subjects the effects of order and practise could be better controlled. Likewise there were no records kept about time spent on the protein modules themselves. Since the activity of producing a map takes time, and probably focuses student attention on more detail in a text passage, it may have been that students using concept mapping spent more time on the module and that it was this factor that contributed to the varied performance.

**Suggestions for Future Research**

The real value of this study is the opening it provides into further research. It would be interesting to run the experimental phase of the project again using a larger sample of students. By gathering more information about the students and their relative academic abilities, balanced groupings might be devised to eliminate several of the possible sources of error. At the same time a questionnaire about attitudes might be given to evaluate formally the students' reaction to the materials.

Another line of inquiry that could follow this project and utilise the same or similar materials would be the comparison of other strategies intended to focus the student's attention on the subject matter at hand and promote more active processing of information. Embedded questions, text highlighting, note taking, outlining, use of illustrations are examples of these. The learning styles of the students might also be determined and comparisons made using this dimension.

A fourth approach is the continuation of the investigation of how the development of knowledge representations or models of a subject matter can be to built into computer assisted learning systems to make them truly adaptive systems. The programme would use this model and a mechanism to keep track of student errors and direct students to repeat parts of the instruction or participate in remediation.

**Overview of the Project**

Although the statistical analysis of the data does not allow one to conclude that using one's own concept map is superior to using the instructor's map while working through structural communications lessons, the use of a concept map was shown to be a valuable aid to students. The project may also be viewed as a successful test of the materials produced: the structural communications lessons and the computer programme. The goal of developing a set of structural communications lessons for nutrition education was achieved by the author. It has also been demonstrated that a computer programme could be developed to mediate the reply to the student using the Hypercard authoring system. Although no data were accumulated about student attitudes towards the format, informal discussion with the students after their completion of the tasks, revealed almost unanimous positive attitudes to the lessons and the accompanying computer programme. Students very much appreciated the extensive feed back which they received about their answers. They also were positive about concept mapping and thought that they would use this technique in future course work. Thus, it seems that this project has been an over-all success and the author would recommend the use of the experimental approach in nutrition education classes.

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# APPENDIX I

# SAMPLE CONCEPT MAPS

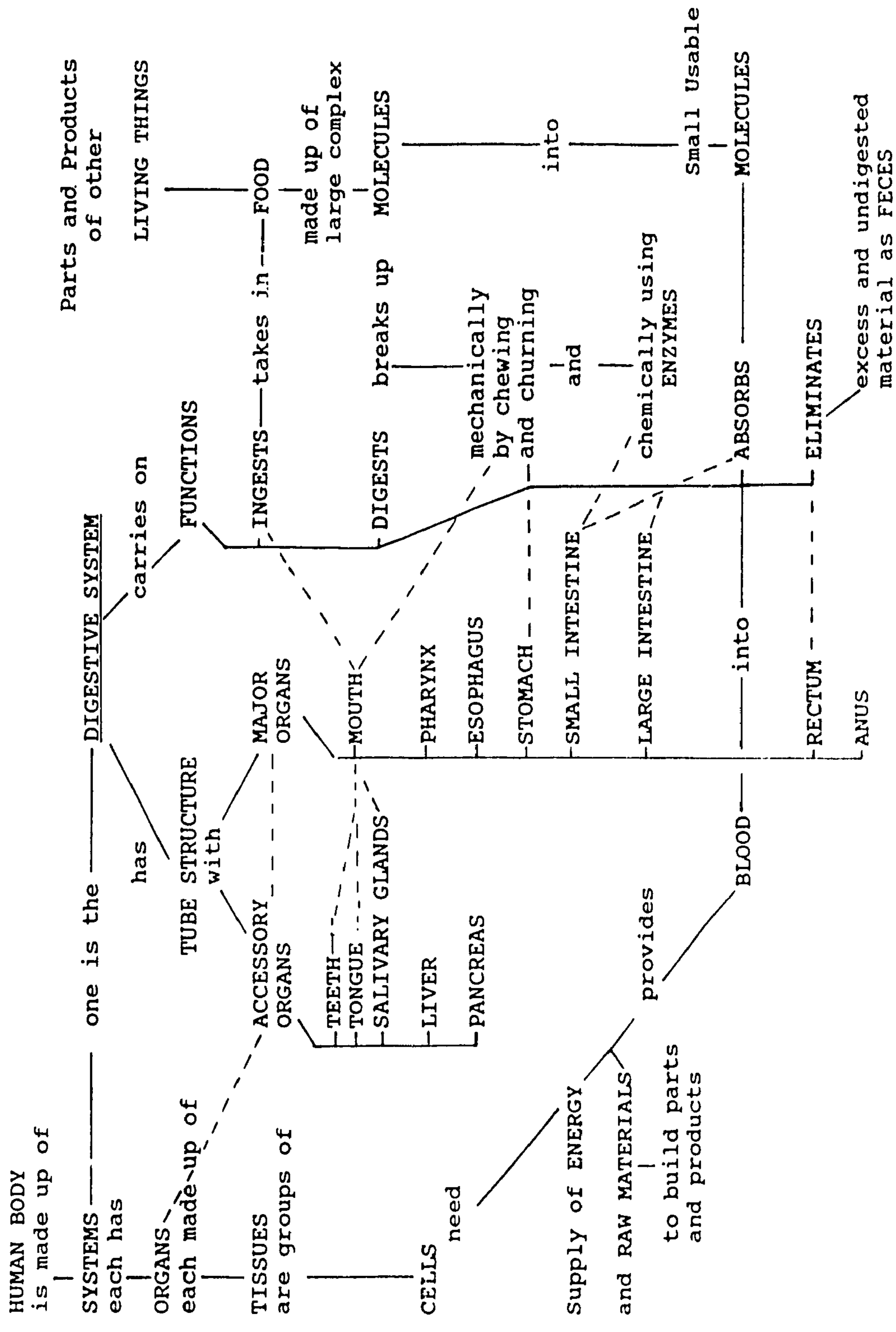



Figure 1: Concept Map for the Digestive System

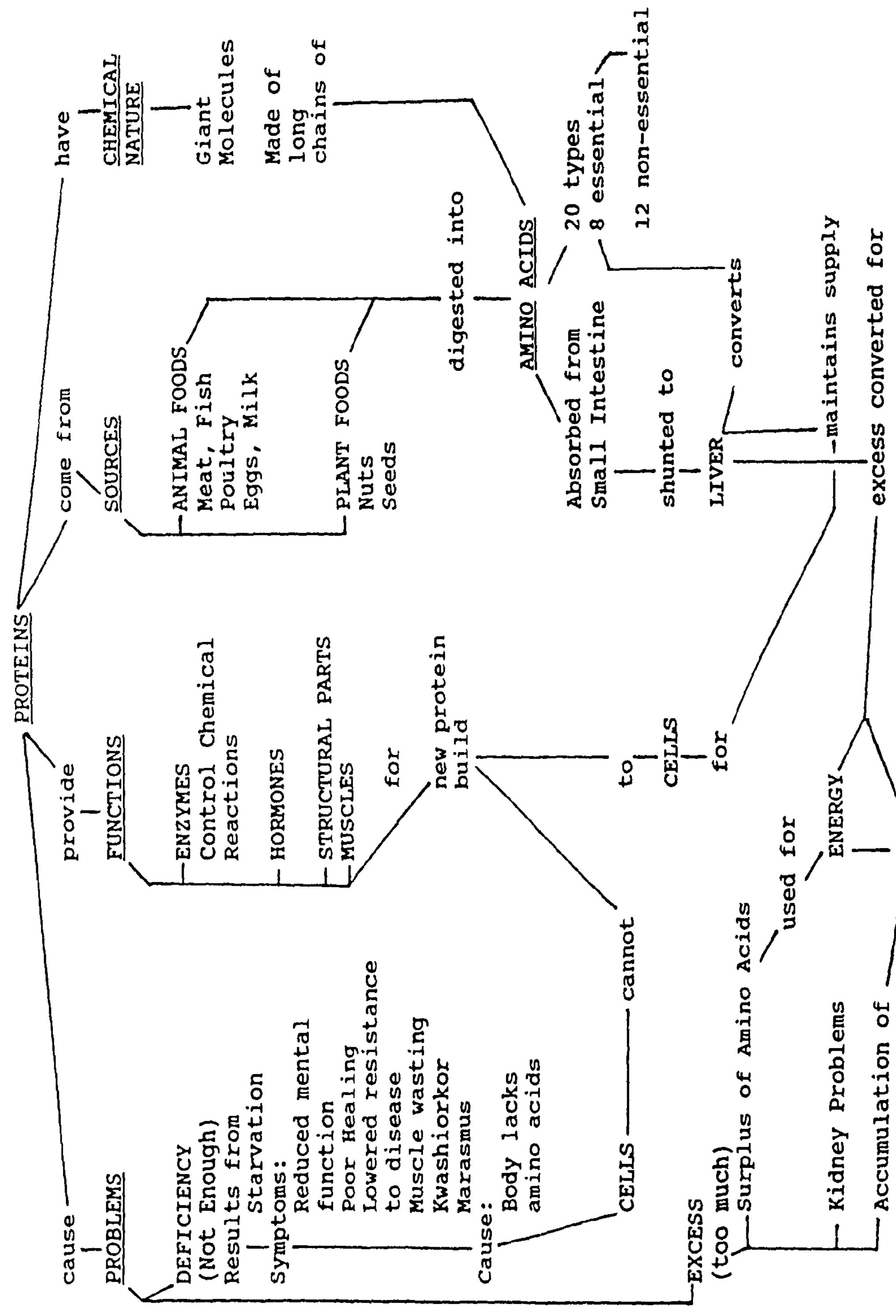



Figure 2: Concept Map for the Proteins

# APPENDIX II

# SAMPLE STUDY GUIDE

# LEARNING FOR EATING

A COMPUTER MEDIATED LEARNING EXPERIENCE IN NUTRITION

USER NAME______________________________________

USER CODE NUMBER________________________________

## INTRODUCTORY MODULE

## WELCOME TO STRUCTURAL COMMUNICATIONS!

During the next little while you are asked to devote your attention to several different tasks designed to increase your basic knowledge of human nutrition, while testing a computer mediated instructional system. This instructional system follows a method known as structural communications. You will use a very structured vocabulary to communicate with the computer which will provide responses to you.

At each point in the lesson, **please follow the directions very carefully** and answer the questions to the best of your ability. Other students participating in this project may be doing very different activities on adjacent computers. Please **DO NOT COMMUNICATE** with your neighbours. If you have a problem of any type, please put up your hand and ask the instructor what to do about it.

This should be a non-threatening experience for you and it is hoped that you will enjoy it as well as pick up some new information. Your name and the user number are going to be used to track data through the programme and the data accumulated are being used to evaluate the materials and not as a means of evaluating you.

## NOTE

All identifying markers will be destroyed as soon as possible after the completion of the research project and all data will be kept in the strictest confidence until then.

Thank you for your cooperation.

## INTENTION

This first module should serve to introduce you to the study of nutrition and the format of the other modules, which will follow. As well, this module will provide some introductory information on the nature of living things, human body structure and the digestive system. This should help provide a context for what follows. During this module you will also begin to use the computer programme through which you will work on this lesson.

## PRESENTATION

Modules: This study of nutrition has been organized as a series of modules. Each module has been developed in an instructional format known as structural communications and consists of four parts. An Intention points out the purpose and objectives of the module and forms links with other modules in the course. The Presentation provides the necessary information. In this case, the presentation is most often written in a text style and must be read as you would read a book. Some diagrams have been included where appropriate. This is followed by the Investigations which are problems or questions to be answered by assembling items from the Response Matrix.

Canada Food Guide: There are several ways to organize or classify food groups. In this unit two schemes are used. A visit to a grocery store will show you another format. First, you will be provided with a copy of the Canada Food Guide. Study it to see the basis of the categories and analyze your intake for a meal accordingly. This guide provides a simple method for balancing your meals according to nutritional principles. As you make a more complete inventory of your diet, you will realize that food may be analyzed into chemical groupings as well.

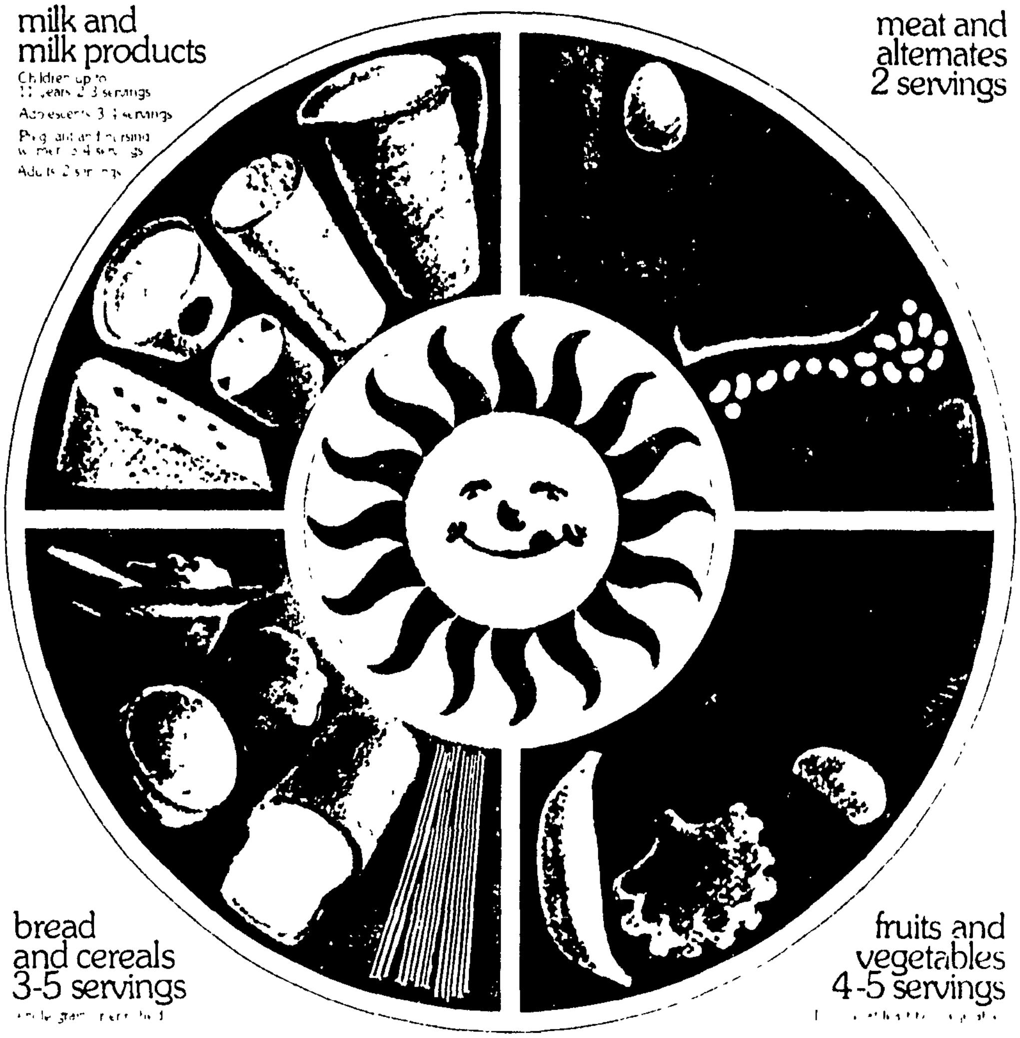
Incidently, the term diet really refers to what we eat. In popular use, the word more often refers to a weight-reducing diet. And while we are on the subject

Canada's Food Guide

# Eat a variety of foods from each group every day

milk and milk products

meat and alternates
2 servings



bread and cereals
3-5 servings

fruits and vegetables
4-5 servings

Canadä

Operation Lifestyle

Canada's Food Guide

# Eat a variety of foods from each group every day

Energy needs vary with age, sex and activity. Foods selected according to the guide can supply 1000-1400 calories. For additional energy, increase the number and size of servings from the various food groups or add other foods.

## milk and milk products

| | |
|---|---|
| **Children up to 11 years** | **2-3 servings** |
| **Adolescents** | **3-4 servings** |
| **Pregnant and nursing women** | **3-4 servings** |
| **Adults** | **2 servings** |

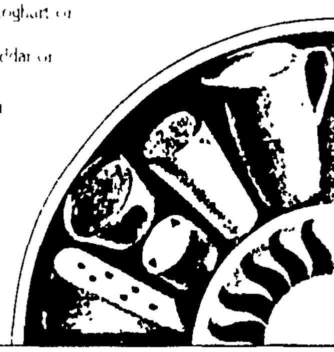
Skim, 2%, whole, buttermilk, reconstituted dry or evaporated milk may be used as a beverage or as the main ingredient in other foods. Cheese may also be chosen.

**Examples of one serving**

250 ml (1 cup) milk, yoghurt or cottage cheese

45 g (1½ ounces) cheddar or process cheese

[illegible]



## meat and alternates
## 2 servings

**Examples of one serving**

60 to 90 g (2-3 ounces) cooked lean meat, poultry, liver or fish

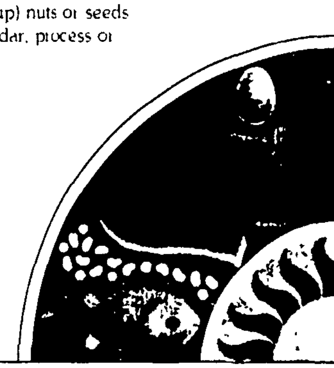
60 ml (4 tablespoons) peanut butter

250 ml (1 cup) cooked dried peas, beans or lentils

80 to 250 ml ( - 1 cup) nuts or seeds

60 g (2 ounces) cheddar, process or cottage cheese

2 eggs



## bread and cereals
## 3-5 servings

whole grain or enriched. Whole grain products are recommended.

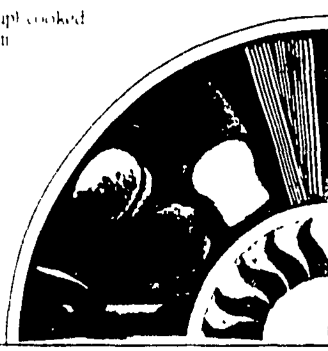
**Examples of one serving**

1 slice bread

125 to 250 ml ( - 1 cup) cooked or ready-to-eat cereal

1 roll or muffin

125 to 200 ml ( - cup) cooked rice, macaroni or spaghetti



## fruits and vegetables
## 4-5 servings

Include at least two vegetables.

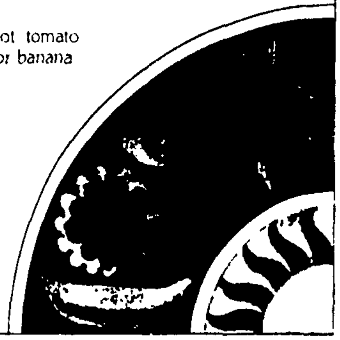
Choose a variety of both vegetables and fruits — cooked, raw or their juices. Include yellow or green or green leafy vegetables.

**Examples of one serving**

125 ml (½ cup) vegetables or fruits

125 ml (½ cup) juice

1 medium potato, carrot, tomato, peach, apple, orange or banana



of terminology, you will need to know about Calories, calories and kcalories. These are the units in which we measure the potential energy chemically stored in the food that we eat. They are determined by measuring the amount of heat given off when a sample of food is burned. In food science, the common measure is the kilocalorie which is equal to 1000 calories. This is sometimes written as kcal or kcalorie. To add to the confusion, the word Calorie, with a capital C, also refers to a kilocalorie.

Anatomy Brief: As living things we have a number of characteristics which are important to understanding our nutritional needs. Our lives follow an important sequence, the life cycle, which includes periods of growth and development as well as reproduction. We maintain a steady internal state that requires the replacement of parts which wear out or are injured. Our bodies are made up of trillions of tiny cells and it is there that the chemical reactions occur that keep us going. In order to operate all this, there is a need for raw material and for energy, which we meet by eating other living things.

The cells are not just thrown together, but are organized in patterns which allow for specialization. Groups of similar cells with similar functions make up what are called tissues. Tissues are arranged in orderly ways to form the organs and the organs work together as systems to provide for general functions. For example, the Circulatory system transports material, nutrients, oxygen, carbon dioxide and wastes throughout the body. One organ of this system is the heart which provides a pumping action. Each artery and each vein may also be considered as an organ of this system. The blood is considered a tissue. There are 10 or 12 body systems depending on how you count. Time does not permit us to discuss them here, but browsing through an anatomy and physiology textbook may help you understand more about these.

The digestive system is important to nutrition. This system can be thought of as a long tube with an entrance at the mouth and an exit at the anus. Along the tube are a variety of specialized organs for specific functions. From the mouth, the chewed and moistened food slides into the throat which is technically called the pharynx. The little ball of food, a bolus, slides into the esophagus to be carried into the stomach. Here acid is added to start the chemical digestion and to kill some of the microbes which enter us with our food. Water is also added to form a liquid mixture which then passes through the pyloric sphincter into the small intestine.

At this point enzymes from the pancreas and the small intestine cells join in to break up the large molecules into smaller ones. Bile from the gall bladder also is added here and helps to digest fats by emulsifying them. During the first few feet of the small intestine, the duodenum, the major process is the chemical destruction of the food. Then as it passes through the rest of the intestine the major nutrient components are absorbed through the intestinal wall. These enter the blood stream for circulation through the body to provide the cells with their supply of energy and raw materials. As the liquid mass passes through the large intestine the excess water is absorbed before the wastes are eliminated through the anus as feces. The blood from the small intestine initially goes to the liver which provides many additional processing functions to make the absorbed nutrients available to the cells. The pancreas provides digestive enzymes, while also helping to regulate the levels of sugar in the blood.

Body Chemical Composition: If a chemical analysis were performed on the body, it would show the body to be composed of some very common elements: Carbon, hydrogen, oxygen, and nitrogen would be very prevalent. Almost every other element would also be found in varying amounts. These elements are arranged in some interesting molecules which we can study as distinct groups: proteins, lipids or fats, carbohydrates, vitamins, minerals and water. Subsequent modules will feature these groups.

## INVESTIGATION

To familiarize you with the structural communications approach and the operation of the computer programme, please attempt the following investigation:

**Trace the path of food through the digestive system by listing in order the parts through which the material passes.**

**To answer this problem:**

Select the items from the **RESPONSE MATRIX** on the next page and the corresponding number present in each block.

You may refer back to the text if you wish.

When you have developed your response, click the mouse on the **START** button on the computer screen, and follow the instructions for entering your choice.

## RESPONSE MATRIX ONE

This matrix is designed to be used with the investigation from the previous page:

**Trace the pathway of food through the digestive system by listing in order the parts through which the material passes.**

| | | | |
|---|---|---|---|
| Blood Vessels 1 | Rectum 2 | Liver 3 | Large Intestine 4 |
| Pharynx 5 | Tongue 6 | Small Intestine 7 | Salivary Glands 8 |
| Heart 9 | Appendix 10 | Mouth 11 | Kidney 12 |
| Stomach 13 | Spleen 14 | Muscles 15 | Pancreas 16 |
| Anus 17 | Gall Bladder 18 | Esophagus 19 | Teeth 20 |

## VIEWPOINT

Another way of looking at the body is as a walking talking chemical factory. Much of what we are and do is the consequence of highly complex chemical reactions operating in each of our seven trillion cells. Each of these reactions has to have a supply of certain substances which are then changed chemically to produce new substances. Chemical reactions involve the transformation of molecules. In some reactions molecules are broken down to smaller components and energy is released to carry out other reactions. In other reactions molecules are assembled to produce new substances. Some of these remain in the cell while others move to other cells or are carried away as wastes. It is food that provides the raw material for the chemical reactions and the role of the digestive system is to process the very large and complex molecules which enter the body into molecular forms that can be utilized by the cells.

When the food enters the mouth it is often in a form that has been organized by the other living things which we consume. Initially, the teeth, tongue and salivary glands start the digestive process by mechanically breaking it up and moistening it. The slippery ball of food slides through the pharynx and into the esophagus for its trip to the stomach. Here water and acid are added to convert the pasty mass to a liquid which will slowly pass into the small intestine through a muscular valve, the pyloric sphincter. In the initial area of the small intestine, a large number of enzymes are added to the mixture which can really no longer be thought of as food.

Enzymes are a special type of chemical in themselves which are produced by cells to act as catalysts. Catalysts control the speed of chemical reactions allowing some reactions to occur at body conditions and preventing reactions from running dangerously out of control. Some of the enzymes needed for digestion are added at the mouth and the stomach. Many are produced by the cells lining the small intestine and still more are produced by the pancreas.

As the mixture passes through the small intestine, bile from the liver is also added to make the absorption of some fatty substances easier. This is done by emulsification, the break up of the oily and grease fats into little droplets which can be dispersed in water. After the chemical break up has occurred, the most of the desired nutrients are absorbed into the blood stream for distribution to the body. Some of these must be further transformed by the liver before they can be of use to the cells. The left over material, the undigested matter and a lot of water pass on to the large intestine. Here there is only minimal nutrient absorption, but most of the water is removed and the wastes are compacted in the rectum prior to elimination through the anus.

**GO ON NOW TO THE NEXT SECTION AND LEARN ABOUT CONCEPT MAPPING**

# CONCEPT MAPPING MODULE

## INTENTION

In this module, you will be introduced to a strategy that should help you to link new material to that which you already know. This is called concept mapping. First, one identifies the major concepts in a body of knowledge and then a diagram is drawn to show how they are linked. An example of concept mapping will be provided and you will use this to solve another investigation on the digestive system.

## PRESENTATION

One way to approach the study of knowledge is to consider it as a construction of smaller related notions or ideas. We may refer to these ideas or units of knowledge as concepts. A concept is identified by a word which seems to produce a mental perception. The word is a type of symbol which stands for this perception. The word chair, for example, generates an image of a four legged piece of furniture with a back used for sitting. In this regard it differs from a table or a couch. We discriminate between items and categorize things based on concepts. Concepts may be shared between individuals and it is possible to introduce new concepts to others. We may agree on concepts or disagree considerably about them. Some major disagreements occur because of poor concept definition which may be described as misconceptions. Concepts may also be modified by linking them with other concepts. If you are told about a red chair you have a different impression than when told about a blue chair. Now you are using the concepts of red and blue in conjunction with the concept of chair.

Concepts may also be linked to form propositions using a variety of linking terms which also may represent concepts in themselves. When we say The red chair is next to the blue chair, we have linked several concepts to produce a proposition which will have different meaning from saying The blue chair is in front of the red chair. Propositions may be judged to be valid or invalid based on how they relate to some situation. Concepts may be very concrete or quite abstract depending on the subject matter that they are part of and the situation of their use.

A technique has been developed to provide a representation of the concepts and propositions of particular subject matter. This technique is known as **concept mapping.** It has been designed to help teachers and students focus upon the key ideas or concepts in the subject matters being studied for particular learning tasks. A concept map provides a view of the subject matter in the same way that a street map might provide a view of a city or town. The concept map helps the user to make links between new material and previously learned material. The map may help a teacher to sequence the instruction so that a student will more easily assimilate the new concepts. The concept maps may also expose a variety of approaches to the subject matter. Often the map can be arranged to produce hierarchies with the broader and more general concepts at the top and the more specific ones further down on the page. Concept mapping provides a means of externalizing concepts and propositions so that they may be discussed between individuals. This often exposes misconceptions which may be better described as persistent invalid propositions. Figure 1 is an example of a concept map for the concept water and Figure 2 shows how the concepts in figure 1 may be rearranged to show other relationships.

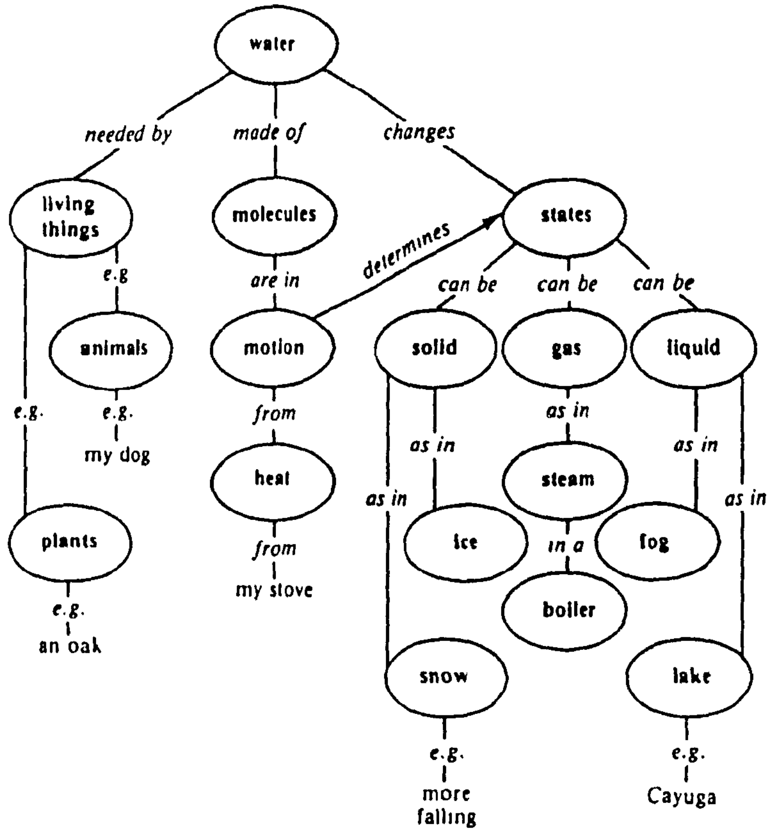



Figure 1: Sample Concept Map for the Concept: Water

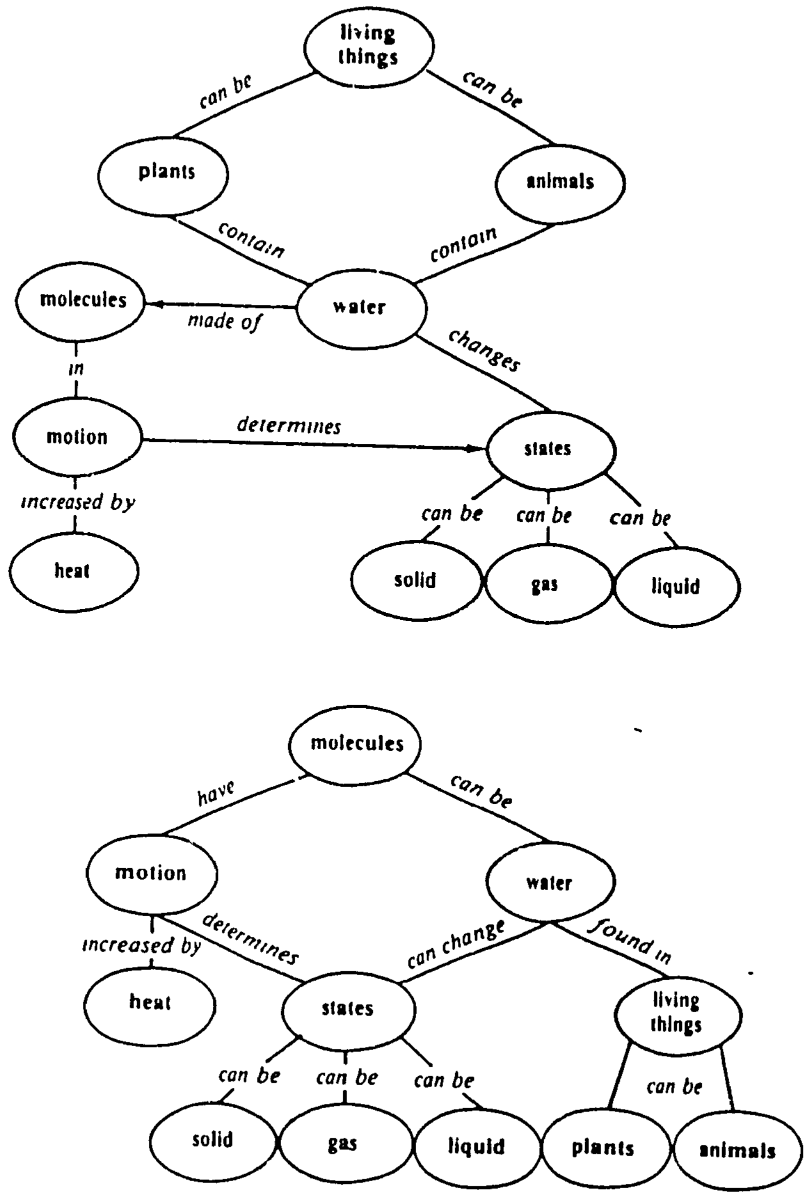



Figure 2: Rearranged Concept Map for the Concept: Water

Note: Figures 1 and 2 taken from: Novak, J.D. and Gowin, D.B.(1984). Learning to Learn. Cambridge: Cambridge University Press.

The materials for the nutrition modules with which you are working in this instructional package have been constructed by using concept mapping techniques. Figure 3 is a copy of the concept map used for the Anatomy Brief that you read in the Introductory Module. If you remove Figure 3 from this text, you can return to the previous pages and compare the text with the map.

After doing this you might realize that the concept map may have been a useful tool in working out the Investigation of the digestive system. Another Investigation of the digestive system is presented on the next page to give you an opportunity to practice the use of a concept map.

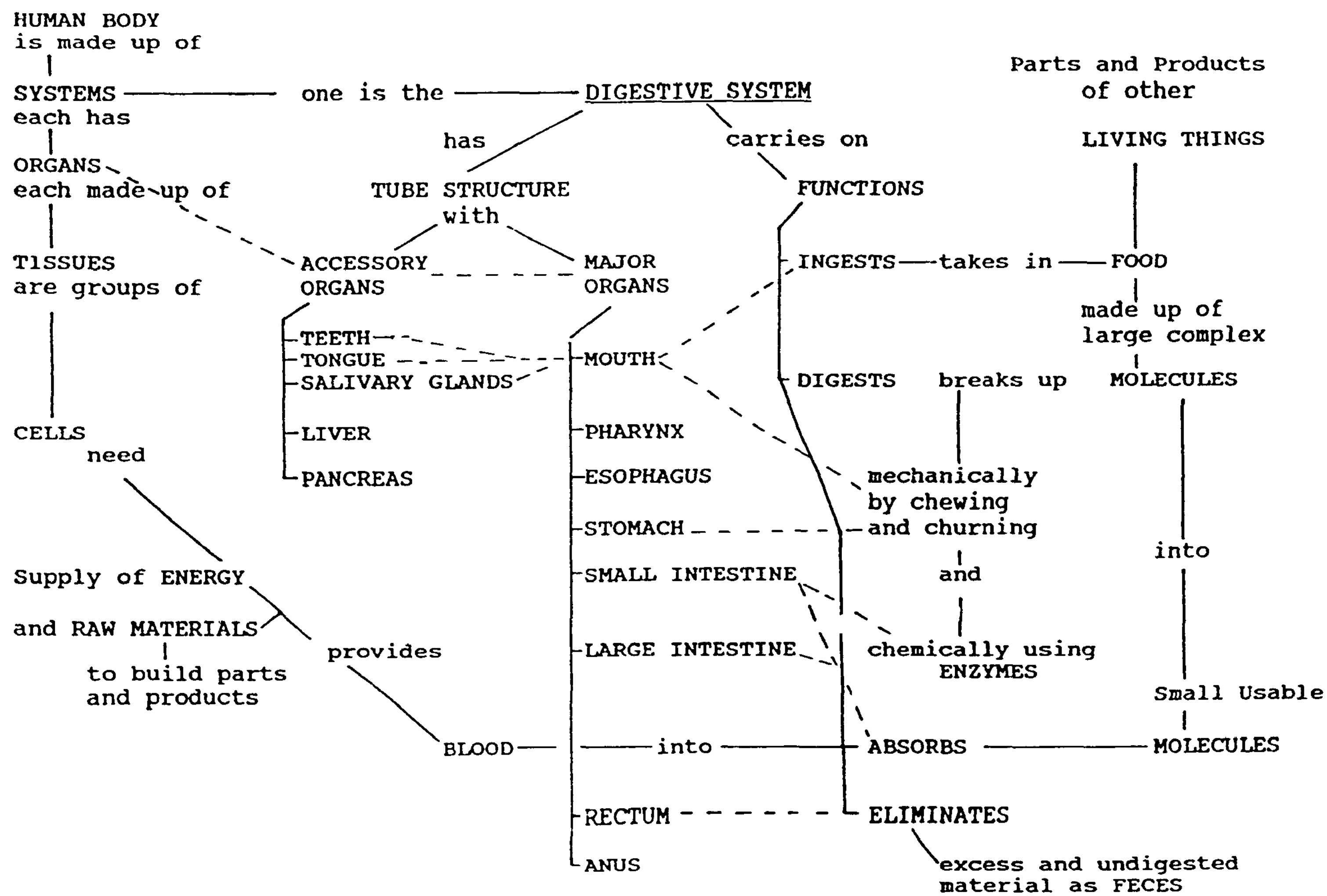



Figure 3: Concept Map for the Digestive System

## INVESTIGATION

Using the concept map of the digestive system (Figure 3) and the Response Matrix on the next page:

**Select those items which will provide a description of the functioning of the digestive system.**
**Again the sequence of the items is important and you should choose your items and then arrange them in a sequence which makes sense to you.**

You will use the computer again to analyze your choices and provide feedback.

You may return to the Introductory Module to check information, although your concept map should be sufficient.

If you need help to start the computer programme, please call the instructor.

## RESPONSE MATRIX : DIGESTIVE SYSTEM FUNCTIONS

**Select those items which will provide a description of the functions of the digestive system.**

**The sequence of the items is important and you should choose your items and then arrange them in a sequence which makes sense to you.**

| | | | |
|---|---|---|---|
| Most absorption occurs in the small intestine. 1 | The digestive system is a long tube with several organs along it. 2 | The wastes are compacted and eliminated regularly as feces. 3 | The opening through which waste is eliminated is the rectum. 4 |
| Drinking liquids with meals may be harmful. 5 | Most chemical digestion occurs in the small intestine. 6 | Not chewing food properly can cause appendicitis. 7 | Enzymes are catalysts which control biological reactions. 8 |
| Our food really consists of the bodies of other living things. 9 | Chemical breakdown is aided by enzymes. 10 | A poor digestion can be blamed on poor liver function. 11 | Food is taken in or ingested through the mouth. 12 |
| Most of the water is absorbed in the large intestine. 13 | Some of the absorbed molecules are used to provide energy. 14 | The undigestible and excess material goes on to the large intestine. 15 | Most chemical digestion occurs in the stomach. 16 |
| Chemical digestion is the sole function of the small intestine. 17 | A daily scheduled bowel movement is an expected function of the digestive system. 18 | The absorbed molecules are the ingredients for cellular reactions. 19 | The small molecules produced by digestion are absorbed into the blood. 20 |
| Digestion is the breakdown of large molecules into smaller ones. 21 | Nutrient absorption is the main function of the large intestine. 22 | Chewing and churning help to mechanically break up food. 23 | Acid and water are added in the stomach. 24 |

**THE NEXT SECTION WILL PROVIDE INSTRUCTIONS FOR BUILDING YOUR OWN CONCEPT MAPS**

## MAKING YOUR OWN CONCEPT MAPS

At this point it seems appropriate to introduce you to the method by which concept maps are produced and to provide you with an opportunity to construct and use a map of your own. There are only a few steps and you will probably catch on quickly. Just follow the steps outlined below:

1. Read over the text you wish to map and select the key concepts necessary for understanding the topic.
   Remember, the concepts are designated by words or terms.

2. Initially, list these words on a sheet of paper.

3. Find the most general or all inclusive concepts and start to rank order or sequence other concepts under them.
   You may wish to make several tries at doing this until you have a satisfactory map.

4. Develop short propositions by using linking words to connect the concepts.

5. Restructure your map as necessary to tidy up the relationships.

6. You may wish to refer to the concept map shown in Figure 3 as a model.

7. To practice this strategy, move on to the <u>FAT MODULE</u> and make your own map of the PRESENTATION before attempting to do the investigation.

8. Use your own concept map to develop an answer to the investigation.

# FAT MODULE

## INTENTION

One chemical group of food substances is the LIPIDS also known as FATS. Eating without fat of any kind is very unsatisfactory, as the fats provide much of what is pleasant about eating: odours, textures and the feeling of satisfaction at the end of a meal are the result of its fat content. In this module, you should find out more about the lipids as a food group and what roles they serve in your body. Current dietary recommendations are included and information about some problems associated with high consumption.

## PRESENTATION

North Americans consume relatively large amounts of fat compared with people in the rest of the world. Since heart attacks, strokes and cancer are the major killers here, some links have been made between our high fat consumption and these diseases. This has given fats in general a bad name. However, we cannot stop eating fat completely as some is vital to our well being. You should realize by now that most of our fat intake comes to us through the consumption of animal products like butter, cream, milk, eggs, meats and poultry. Although most plant parts have very little fat, some nuts, seeds and fruits have high fat content. Some of this fat is concentrated in oils, made by crushing the seeds of plants, and this may be reprocessed to make margarine or used as shortening in food production.

Lipids are large complex molecules and do not readily mix or dissolve in water. A test for the presence of fat is to rub the substance on paper. A grease spot is evidence of fatty substances. There are several very different materials included in this category. Most common are the Glycerides or true fats. These are composed of a backbone of glycerol with fatty acids attached to it. Glycerides come in a variety of forms and are found in plants and animals. Saturated glycerides have a maximum amount of hydrogen attached within the molecules and are usually solids at room temperature. Beef fat, butter and lard are in this category and, as you remember, so are animal fats. Plant fats tend to be mostly unsaturated fats. That is, they contain less hydrogen and are liquids at room temperature.

Another group of fatty substances are the phospholipids which have some phosphorous embedded in their molecules. These are important in the formation of cell membranes. Cholesterol belongs to a group of lipids called sterols. These have rings as part of their molecular structure. Cholesterol is produced by animals and is important in the formation of a large group of hormones including those that regulate sexual function. Lipoproteins are a group of lipids formed by our liver which assist in moving these lipid substances around in the body.

When we consume fatty foods, they require a different processing because of their inability to dissolve in water. Some lipids are broken down by lipase into fatty acids and glycerol as they pass through the small intestine. Others are emulsified which means they are divided into miniature droplets which then can pass through the intestinal wall. Bile contains substances which have this effect.

The liver processes absorbed lipid materials to make them more readily available to the cells that require them. Lipids which are not required are converted into glycerides and stored in fat cells for future use. These fat cells tend to be under the skin and are distributed differently in males and females. Males accumulate fat in a ring around the abdomen which makes a pot belly in the front and the so called "love handles" on the lower back. Females are more likely to deposit fat on the hips, buttocks and leg regions of the body.

Although excess fat may be considered undesirable, lipids provide several essential functions in our bodies. As mentioned earlier, they are important components for cell membranes and hormones. Fatty substances coat over skin to provide waterproofing and the wax in our ears is a lipid product. Fats provide padding in certain areas and some organs are protected or held in place by fat deposits. Insulation, to help maintain body temperature, is another function. The fat soluble vitamins, A, D, E and K, are absorbed with fat and stay in the body longer than the water soluble B and C vitamins as a consequence.

In North America, fat deficiency is almost unknown. Even people suffering from other protein and vitamin or mineral deficiencies rarely show any fat deficiency. More likely it is the excess of lipids which cause trouble. North Americans generally consume 40-50% of their daily caloric intake as fats. If you don't believe this look around at the ready availability of fat in our snack foods. A potato has almost no fat in itself - but 14 potato chips weighing 28 grams deliver 10 grams of total fat and 148 calories. The problems caused by excess fat can be discussed under three categories: obesity, cardiovascular disease and cancer.

When people are more than 20% overweight for their height they are defined as obese. This condition can put a strain on the body in general and can overwork the heart. Obese people often get into a cycle of eating more, doing less and gaining more weight. Professional help is advised to overcome this problem.

Cardio-vascular disease is also related to high fat intake and there is substantial evidence that high cholesterol intakes contribute to increasing risk of this disease, at least in some people. Cardio-vascular disease is the usual cause of heart attacks and strokes. Deposits of cholesterol accumulate in the blood vessels reducing their size and increasing blood pressure. Sometimes clots are formed at these spots and other times the vessels break. The consequence is much the same, the tissue nourished by the vessel is cut off from blood supply and thus it does not receive oxygen and nutrients.

The link between excess dietary fat and cancer is less definite than in heart disease. However there is some evidence that the high fat diet is associated with other risk factors to contribute to increased cancer risk.

To avoid the problems associated with high fat intakes, there are recommended fat intakes. Like many of the dietary recommendations, there is a controversy about the amounts. However, the current consensus is to reduce fat intake to 25 to 30% of daily caloric requirements. Dieticians also recommend restricting cholesterol to less than 300 mg per day, although there is more controversy surrounding this amount.

Finally, remember that your sense of well being and satisfaction requires some lipids, so enjoy their positive effects.

## INVESTIGATION

Use your concept map and the response matrix on the next page to develop an answer to the investigation below:

> **Although we are cautioned to avoid high intakes of lipids, we must consume some of these substances. Describe the benefits derived from lipids.**

When you have your answer ready, you may enter it into the computer programme as you did previously.

If you need help, call the instructor for advice.

## RESPONSE MATRIX - FAT MODULE

**This response matrix is to be used for any of the INVESTIGATION on the previous page:**

**Although we are cautioned to avoid high intakes of lipids, we must consume some of these substances. Describe the benefits derived from lipids.**

| | | | |
|---|---|---|---|
| We take in some fat with our meats. 1 | Sterols are ring shaped fats which are found in hormones. 2 | Our body fat helps to insulate us against the cold. 3 | People more than 20% overweight are considered to be obese. 4 |
| Glycerol is a high energy substance 5 | Fats in our meals provide the feelings of satisfaction. 6 | There seem to be links between certain types of cancer and high fat intakes. 7 | The yolks of eggs are rich in fats. 8 |
| Currently, dieticians recommend that people restrict their fats to less than 25% of their caloric intake. 9 | Vitamins A, D, E, and K require fat for their absorption. 10 | Fat can be taken out of storage to provide energy. 11 | Fatty substances do not dissolve in water. 12 |
| Fat deposits provide padding in certain areas of the body. 13 | The body can easily reassemble glycerol and fatty acids to form fat deposits. 14 | Phospholipids are a type of fat found in cell membranes. 15 | Many snack foods like chips and cookies are loaded with fats. 16 |
| Although most plant materials are low in fat, nuts and seeds may contain a considerable amount. 17 | Glycerides are digested into fatty acids and glycerol. 18 | The oils in our skin, and the wax in the ears are examples of substances made from fats. 19 | Butter and cream are mostly fat. 20 |
| The cardio-vascular system diseases of strokes and heart attacks are often a result of high fat diets. 21 | Fatty acids are of two types saturated and unsaturated. 22 | Steak tastes good because of its fat content. 23 | Glycerides are one type of fatty material. 24 |

## VIEWPOINT

If we continue to apply the analogy of a chemical factory to the body, the fats can be considered to be the walls and storage centres of the factory. Living things live in watery environments. Those of us that live on dry land maintain a watery environment within ourselves and have perfected, to varying degrees, the ability to keep the water inside. Because the lipids do not dissolve in water and are even resistant to being washed away, they are ideal partitions of the internal environment.

Around each cell is a plasma membrane that is a collection of phospholipid molecules which provides an effective barrier between the cell and its environment. Some materials are allowed to pass through this membrane to either enter the cell as raw material or fuel or to leave as the products of the cell's activity or as wastes of the processes. Within the cell itself there are other membranes which partition off the various cell structures or organelles and serve similar functions. Some cells have a fatty material around the outside to insulate their activities from those of their neighbours.

There are some specialized cells which store up fatty deposits to create pads of fat which might act as storage of energy. Fat molecules contain many chemical bonds which can be broken to liberate energy in time of need. Unfortunately, these fats are also very stable and remain stored for long periods of time. Some of the stored fat also serves the function of insulating the body against the cold. Other fat deposits are used as padding to hold certain organs in place.

Then there are some special oils made by cells in the skin and hair to help waterproof these and keep us from drying out or getting too soaked. The wax in the ears provides a protective barrier against water, dirt, insects and debris for the sensitive eardrum. Some fats are utilized to make hormones, those chemical messengers which regulate our body chemistry.

Fat is a necessary part of most people's diets, but many of us in North America overdo it. Since it tastes good or makes things taste good when it is an ingredient, it is always tempting to eat more. Unfortunately, heart attacks, strokes and some forms of cancer seem to be linked to our high fat intakes. Currently, nutritionists recommend that we limit fat intake to less than twenty-five percent of our calorie needs each day.

Eat fat with moderation and live longer to enjoy it!

Hopefully, you have started to develop the technique and you are ready to move on and apply it to the **Protein Module.**

When you are ready, please **ASK THE INSTRUCTOR** for the PROTEIN MODULE.

## PROTEIN MODULE

### DIRECTIONS:

READ OVER the text materials carefully.

CONSTRUCT your own CONCEPT MAP for the Presentation section of this module.

UserName________________________________________

User Number_____________________________________

When you are ready for the Response Matrix, Please ASK THE INSTRUCTOR to provide it. The computer will be set for you at this time.

## INTENTION

In the introduction module, you categorized your food into four major food groups following the Canada Food Guide: meat, dairy, fruits and vegetables, and breads and cereals. You also were shown another way of grouping foods into categories based on their chemical constituents. These categories are proteins, carbohydrates, lipids or fats, vitamins, minerals and water.

In this module, you will work with proteins to learn more detail about this group. You should find out more information about the nature of protein and their fundamental units, the amino acids. You should come to realize why we eat protein and what we do with it once it is eaten. You should also have a better idea of how much protein is required and what happens when there is too much or too little.

## PRESENTATION

Some time today you probably ate some protein rich food: eggs, cheese, meat or milk. What value do proteins have and what happened to them once inside the body? You may wonder if you ate enough or you may actually overeat from this category. Since almost all of our food comes from the parts of other living things, it is hard not to consume some protein at every meal or snack.

First let's look at the structure of proteins. These are giant molecules called polymers which are made up of chains of other molecules. It is these units of protein - the amino acids - which are really important to us. An analogy may be made to a string of coloured beads. The string can be assembled using a variety of sequences and patterns. These patterns can be duplicated and reconstructed if the pattern is described. Once strung together the string may be coiled, folded, or wrapped around in a variety of ways. In a protein molecule, the beads are the amino acids.

There are twenty different amino acids found in nature. Since the amino acids can be arranged in many different sequences and lengths, there are many different types and sizes of protein. The chains can be folded, bent, wound and/or spiraled to provide a variety of shapes. These patterns are determined by the genetic code of the organism.

Once we consume protein, the chains are broken up into amino acids as a consequence of the acids in the stomach and enzymes in the small intestine. Since the amino acids are smaller than protein molecules, they are absorbed into the blood and shunted to the liver, that giant food processing organ.

Before continuing with the tale of what happens to amino acids, it is useful to consider their origins and some of their properties. Amino acids contain the chemical element nitrogen along with carbon, hydrogen, and oxygen. Plants are particularly good at synthesizing amino acids from nitrogen absorbed from the soil in the form of nitrates. These amino acids are assembled into plant proteins. Animals consuming plants acquire these amino acids and can convert some amino acids into other ones.

Of the twenty amino acids, humans can synthesize eleven, provided we have consumed the other nine. These nine amino acids are called Essential Amino Acids. When the liver receives amino acids from the intestine, it can reprocess some of these essential amino acids to provide a supply of the non-essential amino acids. The liver also stores amino acids and gradually releases them to maintain a constant supply for the individual cells of the body. In the cells, the amino acids are constantly being reassembled into specific types of proteins as determined by our genetic code. The names of the amino acids are included in Infobox 1.

| INFOBOX ONE: AMINO ACIDS | | |
|---|---|---|
| ESSENTIAL | NON-ESSENTIAL | |
| Histidine | Alanine | Serine |
| Isoleucine | Arginine | Tyrosine |
| Leucine | Asparagine | |
| Lysine | Aspartic Acid | |
| Methionine | Cysteine | |
| Phenylalanine | Glutamic Acid | |
| Threonine | Glutamine | |
| Tryptophan | Glycine | |
| Valine | Proline | |

If a person consumes a lot of protein, there will be an excess of amino acids. Of course, if one consumed more food than can be processed by the digestive system, some of it is wasted in the feces. The liver deals with excess amino acids by removing the nitrogen and excreting it through the kidneys. This requires additional water for excretory purposes. The other parts of the amino acids are then converted to substances which can be utilized for energy. Again, if there is no momentary need for energy these substances are converted to fat and stored. Many North Americans consume an excess of protein and accumulate body fat from this source.

Deficiency of protein is a serious problem as the body's cells lack the amino acid components to build their own protein molecules. Extreme deficiency is illustrated by the pictures of the starving people of the world showing wasted muscles and bloated bellies. This condition is known as Kwashiorkor. Marasmus, another condition of extreme protein deficiency is caused by lack of both protein and energy containing foods.

Less extreme deficiencies can occur closer to home. The poor, the homeless, and the elderly are often seen with protein deficiencies. Those people obsessed with maintaining a super thin body and followers of "fad diets" or starvation plans may also suffer from a protein deficiency. Adoption of a vegetarian lifestyle without adequate planning and knowledge can inadvertently produce protein deficiency symptoms. These range from muscle wasting and reduced mental function to increased susceptibility to infection, stunted growth or development, and delays in the healing of wounds or injuries. Since the consumption of other foods is also usually reduced, people with protein deficiency will also have vitamin and mineral deficiencies as well.

Now, having described excesses and deficiencies, how much protein is recommended per day. Although there are controversies about the specific requirements, there seems to be an agreement that about 0.8 grams of protein should be consumed by healthy adults for every kilogram of body weight. Therefore, multiply your weight in kilograms times 0.8g to get your approximate intake requirement. This requirement assumes that energy needs are provided by carbohydrates and fats and has a built in adjustment for growth and repair. Obviously growing children require more protein and, if you are in your late teens, you can increase your requirement slightly to 0.85 g/kg of body weight. For years, athletic individuals have often been fed high protein meals like steak and eggs while in training. Dieticians do not agree on requirements for these people. However, if you are training, you may wish to increase your intake slightly. Pregnant women need about 30 grams extra per day above their personal needs and nursing mothers are advised to consume about 20 grams extra to provide nutritious milk.

From your food groups introduction you should realize the kinds of food which provide good sources of protein. Animal food products such as meats, poultry, eggs, fish, milk, and cheese are considered good high quality sources of protein. Because plant proteins may not deliver an adequate supply of essential amino acids they are often considered to be of lower quality although one of the notable exceptions is soybeans.

## INVESTIGATION

Use the CONCEPT MAP that you have constructed for this module about PROTEINS
and the RESPONSE MATRIX on the next page to develop an answer to the investigation below:

> **Almost all foods contain some protein, but some foods are protein rich. If you consume a protein rich food like steak or eggs, what does your body do with it?**

## RESPONSE MATRIX - THE PROTEIN MODULE

**Use this matrix to respond to the INVESTIGATION:**

**Almost all foods contain some protein, but some foods are protein rich. If you consume protein rich food like steak or eggs, what does your body do with it?**

| | | | |
|---|---|---|---|
| The average adult requires 0.8g of protein per kilogram of body weight daily.<br>1 | Protein deficiency may lead to reduced mental functioning.<br>2 | Egg white is mostly protein.<br>3 | Protein molecules are giant molecules made up of smaller units called amino acids.<br>4 |
| The liver converts excess amino acids to a form which can be used for energy.<br>5 | Some seeds and nuts are particularly rich in protein.<br>6 | High protein intakes cannot add fat to the body.<br>7 | Our body cells use amino acids to construct their own proteins.<br>8 |
| The daily protein intake must provide an adequate supply of amino acids for protein synthesis.<br>9 | The absorbed amino acids are moved to the liver.<br>10 | Kwash'orkor is an extreme form of protein deficiency in which a person has muscle wasting and a big belly.<br>11 | People with low protein intakes often show poor healing of injuries.<br>12 |
| Cheeses and Milk are good sources of protein.<br>13 | Muscle wasting is a sign of a poor protein intake.<br>14 | The liver maintains the supply of amino acids by converting the essential amino acids into the non-essential ones.<br>15 | Meats, as the muscles of other animals, are one of the most common sources of protein<br>16 |
| Taking vitamin pills daily will help to avoid a protein deficiency.<br>17 | The digestive system breaks down the proteins in our food into amino acids.<br>18 | If there is no need for energy, excess amino acid remains may be converted to fat.<br>19 | Stunted growth may be a sign of protein deficiency in children.<br>20 |
| Adopting a vegetarian diet requires special attention to ensure adequate amino acid intake.<br>21 | Organ meats, such as liver and heart are rich protein sources.<br>22 | Amino acids are absorbed by the small intestine.<br>23 | Egg yolk contains a lot of proteins<br>24 |

## VIEWPOINT

We are what we are because of our proteins. These are the structural and functional elements of our body. The genetic programme that we each inherit at conception determines the wide array of protein found in each of the cells. Our biochemical reactions are regulated by a group of proteins known as enzymes. These are the catalysts that speed up or slow down the reactions allowing them to occur in the conditions provided by the body. Other living processes are regulated by protein hormones. When you have suddenly been scared by something, you have felt the effects of the hormone adrenalin. This is a protein that is moved rapidly around the body through the blood stream and sets up a reaction called the "fight or flight response". Our muscles contract because of special protein units that shorten when stimulated. Other more obvious protein structures are our hair and nails.

In order to build its proteins, the body requires a supply of smaller molecules known as amino acids. We get these by digesting the proteins of other living things. After the giant protein molecules are broken up, the amino acids are absorbed through the intestine into blood which goes to the liver. The liver regulates the supply, by storing some and transforming others to make the non-essential amino acids. The unused amino acids can be converted to a form that can be consumed to provide energy or stored as fat. Neglecting the protein component of the diet can lead to serious consequences because we will not have sufficient amino acids to build our own protein.

The word protein comes from the Greek word meaning "to take the first place", and was given to these compounds because it seems that life as we know it could not exist without them. Now that you know a bit about them, it should occur to you to always plan to eat enough when you are selecting foods to eat!

## THANK YOU VERY MUCH

I hope that you have gained some knowledge about nutrition and learned a little about concept mapping which you can put to use in studying other courses.

You may have the text materials about nutrition and concept mapping that you have worked with in this project. However, they must be retained until the experiment is finished later in the summer.

Look for a notice in the Fall or leave your name and address and they will be sent to you.

Thank you again for your time and cooperation and

**HAPPY EATING!!!**

# APPENDIX III

## SAMPLE COMPUTER SCREENS

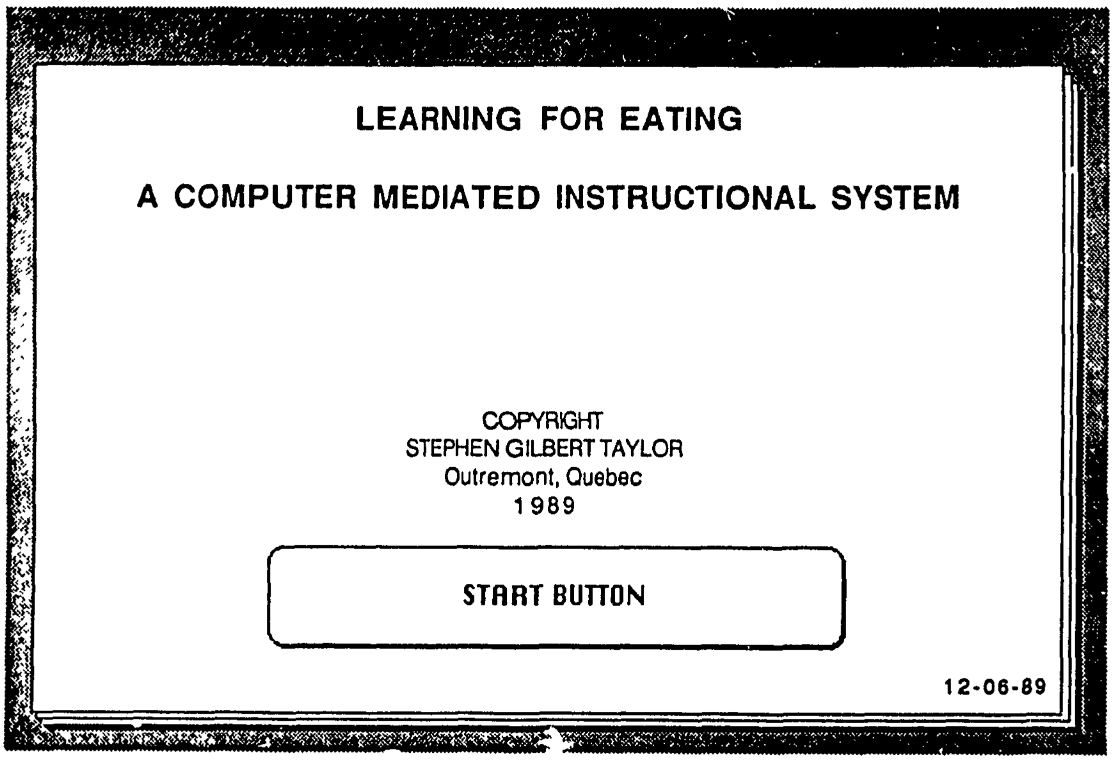



Figure 1: Title Screen
Activating the Start Button reveals several screens of instructions on use of the programme.

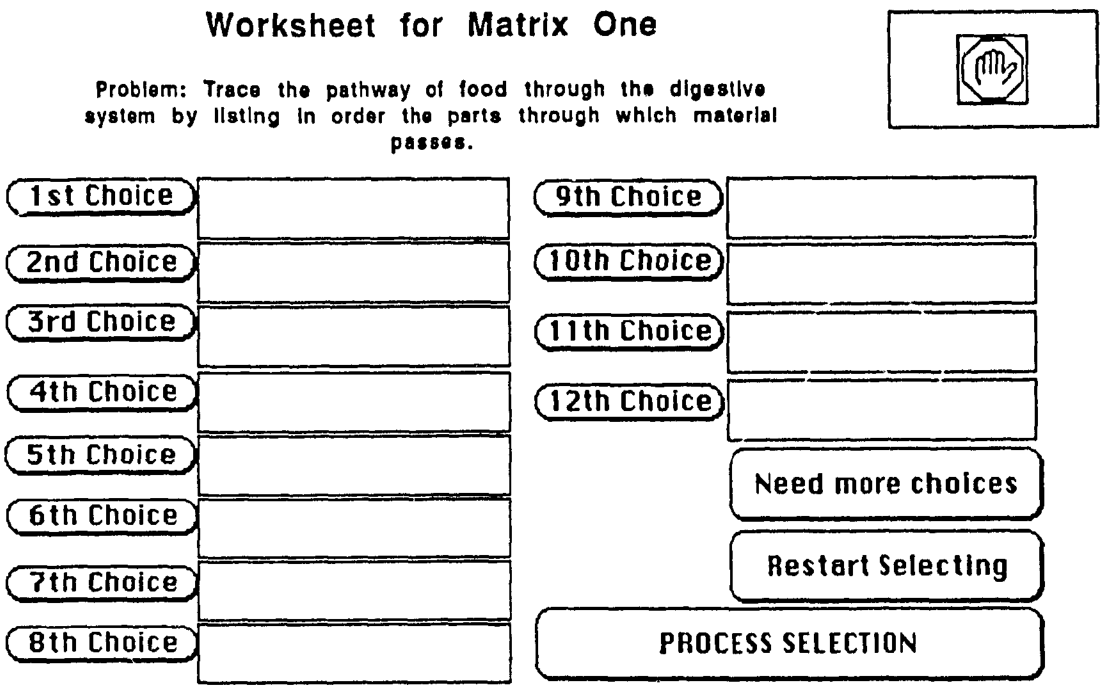



Figure 2: Worksheet for Matrix One
Activating a <u>Choice</u> <u>Button</u> asks the user for the number of a selected matrix item.

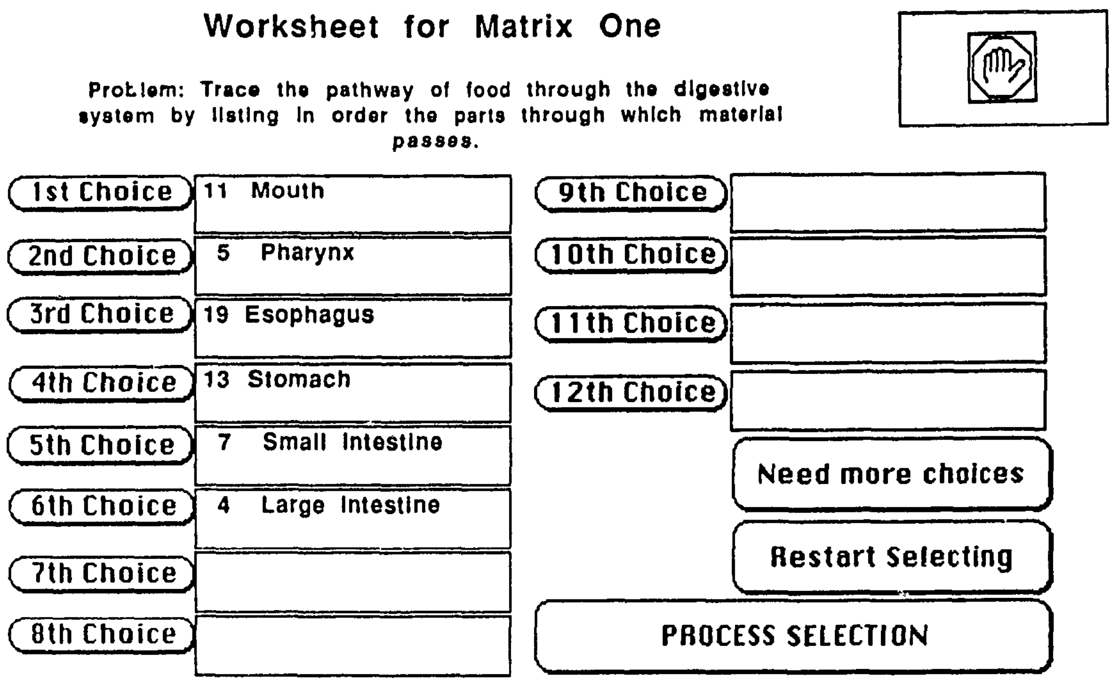



Figure 3: Worksheet for Matrix One Partially Completed Activating the Process Selection Button will begin the analysis of the user's choices.

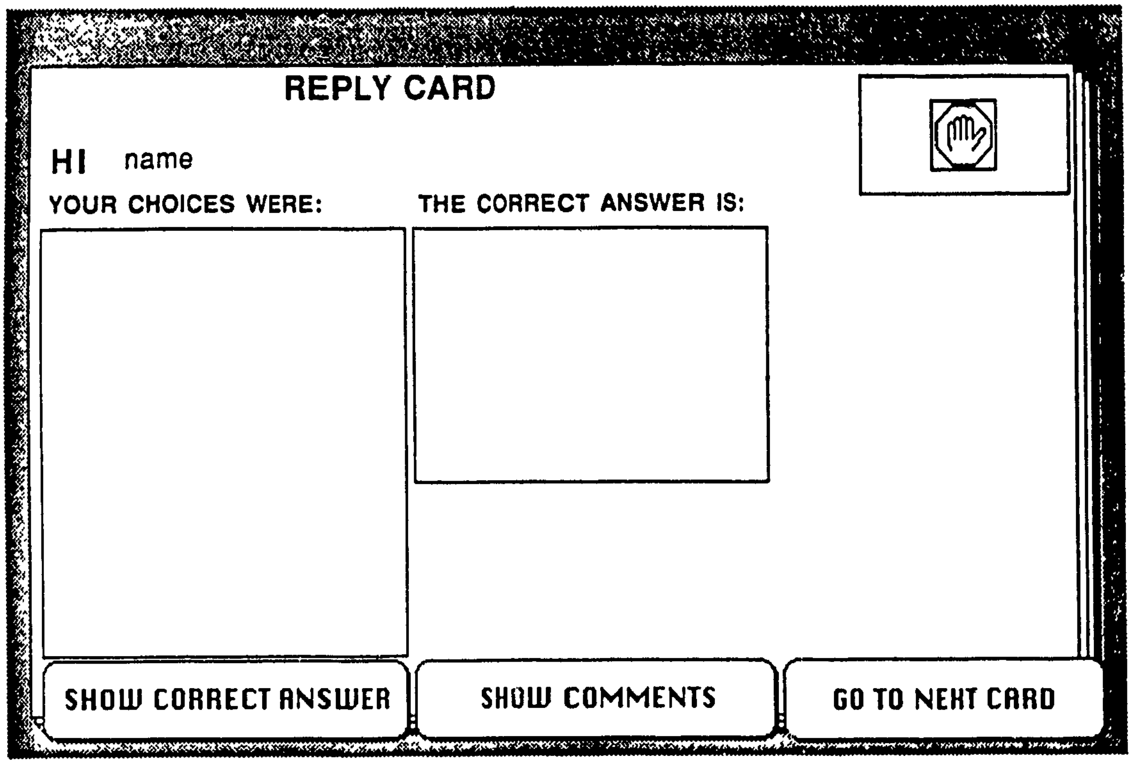



Figure 4: First Reply Card
The user receives initial feedback from this card and can compare the entered answer with the correct answer.

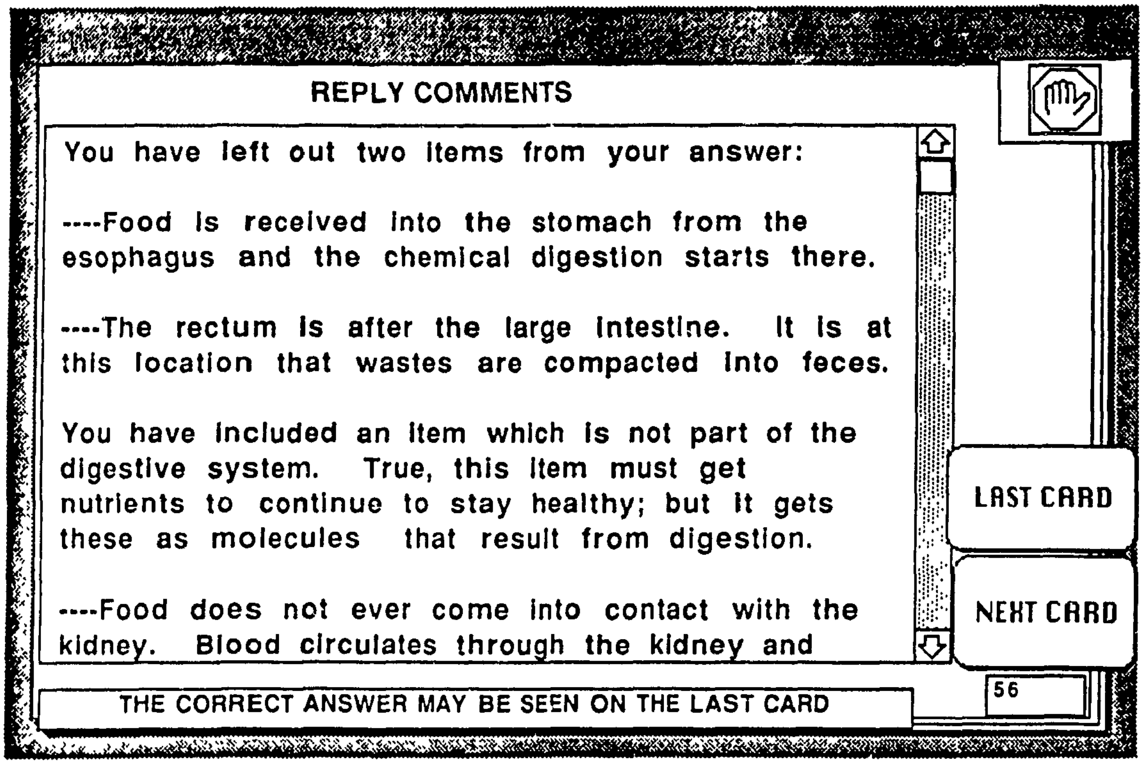



Figure 5: Reply Comments Card
Extensive comments to the user are provided in the scrolling field of this card.