SIMULATIONS AND GAMES FOR TEACHING THE QUEBEC SECONDARY I. ECOLOGY AND THE SECONDARY III. HUMAN BIOLOGY PROGRAMS

by

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Monograph

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ABSTRACT

In this monograph, a brief account of the content of the Quebec Secondary I. Ecology, and Secondary III. Human Biology Programs is presented. For this purpose, both Curriculum Documents and the accompanying Curriculum Guides were used.

The main purpose was to identify and isolate those concepts for which the search has revealed simulations and/or games considered to be an appropriate aid for teaching. With respect to the Ecology program, seven major categories were selected: (i) Characteristics of Living and Non-living Things, (ii) Predation, (iii) Natural Resources, (iv) Pollution, (v) Plants, (vi) Food Chains and (vii) Population.

In regards to the Human Biology program, again seven major topics were selected: (i) Cardiovascular System, (ii) Digestion, (iii) Locomotor System, (iv) Nervous System, (v) Reproductive System, (vi) Sense Organs, and (vii) Human Body. Of these seven categories, simulations and/or games for the first six topics are described. The treatment of the Human Body category has been omitted because many concepts overlap with those already mentioned under the others. In all, there have been twenty-four simulations and games selected for the Human Biology program, of which twenty are described here.

RÉSUMÉ

Dans cette monographie, un bref compte du contenu de l'Écologie du Sécondaire I du Québec et de la Biologie Humaine du Sécondaire III du Québec est presentée. Dans ce but, les deux programmes documentaires et les guides d'accompagnement ont été utilisés.

Le but majeur a été celui d'identifier et d'isoler ces concepts pour lesquels la recherche a révélée simulations et/ou jeux considérés comme étant une aide appropriée pour l'enseignement. En ce qui concerne le programme de l'Écologie, sept catégories majeures ont été choisies: (i) caractéristiques des êtres vivants et non-vivants, (ii) prédation, (iii) ressources naturelles, (iv) pollution, (v) plantes, (vi) chaîne alimentaire et (vii) populations. Le tout ensemble, vingt et un simulations et/ou jeux ont été sélectionnées pour le programme de l'Écologie.

En ce qui concerne le programme de la Biologie Humaine, de nouveau sept majeurs sujets de discussion ont été sélectionnée: (i) système cardiovasculaire, (ii) digestion, (iii) système locomotif, (iv) système nerveux, (v) système reproducteur, (iv) organes des sens, et (vii) le corps humaine. De ces sept catégories, simulations et/ou jeux pour les six premiers sujets sont décrits. Le traitement de la catégorie du corps humaine a été négligée, car plusieurs concepts se chevauchent avec ces déjà mentionnés en dessous des autres. En tout il y a eu vingt-quatre simulations et jeux sélectionnée pour le programme de la Biologie Humaine, ce dont vingt ont été décrits ici.

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GENERAL INTRODUCTION

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General Introduction

1. Introduction

Public education, particularly science education, is once again the target of reform. In the future, the concept of science as an entity in society and in the curriculum--separate from the community and its life style, values and culture--is no longer tenable. Consequently, many educators today believe that there is a need for curriculum that focuses on society and societal problems and that concerns itself with educating young people who will be flexible in outlook and ready and willing to accommodate change.

In the western world, the present state of science education is of great concern to us all. Problems of declining student enrollment and subsequent teacher lay-offs are threatening the quality of science education in public schools. In Montreal schools, cases of physical education instructors teaching ecology, instead of biology teachers, are media news (Aubin, 1988). Dr. Gilles Dusseault, of the Universite du Quebec a Hull, confirms that, in this province, secondary school science is very often taught by teachers whose expertise lies in fields other than science (Aubin, 1988). Low test scores, low learning expectations and disinterest in science are the products of all these

influences on the students. Moreover, recent statistics show that Canadian and American high school students rank lower in science and mathematics than do their counterparts in many non-industrialized countries (Aubin, 1988 and Green, 1989). The elementary school science curriculum and instruction is deficient, as it is currently presented in many schools in Canada. Few, if any, elementary teachers have a strong science background (Smith, 1984). Since 1970, Dr. Pearl Francoeur's efforts to promote science-course background requirements for elementary school teachers-in-training at McGill University's Faculty of Education, in Science Education, met with faculty resistance and lack of support (Aubin, 1988). High school graduates' interest in pursuing post-secondary science courses has dwindled over the past 23 years (Green, 1989). Studies also reveal that in the United States many college freshmen who choose science as their Major, tend to abandon science for non-science fields (Green, 1989).

News of science education lagging behind in Canadian schools is a frequent topic of media coverage. Concerns for the "low-know" generation are being echoed across Canada. There is unanimous agreement that the goals and courses introduced by the science curriculum reform movement of the 1960's, and many of the courses introduced in schools during the 1970's do not satisfy the needs and objectives of science-

technology related problems in this day and age. A formulation of new goals for the teaching of science in schools has thus become mandatory.

Efforts to reform science education are, nevertheless, underway. The grandiose deliberations of the Science Council of Canada (Smith, 1984), and those of the American Association for the Advancement of Science in collaboration with the National Council on Science and Technology (Project 2061, 1989), are of prime importance. These education reform initiatives are presently being introduced in both Canada and the United States. These provide evidence that there is a consensus among science education leaders who believe there is an urgent need to initiate changes in science education. To help initiate and guide change in the educational system, the following major recommendations have been proposed:

1. Science education must be comprised of science, mathematics and technology.
2. Science education should be accessible to all.
3. Science education should have scientific literacy as its central goal.

Science Education

The interdependence of science, mathematics and technology forms the reason for their inclusion in science education.

The justification for this lies in the fact that technology depends on the principles of science and the models of mathematics. This is evident in the following instances:

(i) biotechnology (genetic engineering, recombinant DNA and deliberate protein synthesis) is the direct result of the bioscientists' discoveries of DNA, its molecular structure, and the mechanism of protein synthesis, and (ii) the mathematical logic of the three ideas, "and", "or" and "not" forms the basis for computer operations.

On the other hand, science and mathematics benefit from technological tools, such as the electron microscope and electronic computing devices.

Growing scientific knowledge and technological power is causing a shift in the basic education necessary for living in the future.

The substance of science education outlined in Project 2061, an American initiative, includes the knowledge, skills, values and attitudes associated with science, mathematics and technology.

Knowledge: It encompasses the nature of science, mathematics and technology; the architecture of the universe; all living organisms; mankind and his society; the designed world; the mathematical world; scientific discoveries in historical perspectives and common themes that explain various natural and abstract phenomena.

Skills: The most highly valued skill is problem-solving because it utilizes many other skills.

Therefore, the U.S. initiative makes recommendations for the following basic skills:

- mathematical computation
- manipulation and observation
- communication
- critical response
- information processing

Values: Science education should be instrumental in developing science, mathematics and technology related values in learners. It should also reinforce certain social values, such as curiosity, openness to new ideas and systematic skepticism.

Attitudes: It has been noted that many students leave high school with a negative attitude towards science and mathematics. Teaching practices are known to play an important role in changing attitudes towards a subject. Therefore, teachers should foster positive attitudes towards learning science and mathematics. To achieve this goal, the U.S. Reform Initiative suggests that teachers should:

- Select accessible, exciting and significant topics
- focus on exploring and understanding, rather than the rote memorization of terms
- guide and instruct exploring procedures

- promote team work and/or competitive work
- acknowledge the achievements of their students

Science For All

Science education is prescribed for all children. Therefore, it follows that children of all ages, levels and ethnic backgrounds, as well as both genders, should have access to a quality science education. This education should also cater to the individual differences of gifted students, high-achievers, slow learners, the science-oriented and non-science-oriented alike. Science should be taught to those planning careers in science as well as to those without such ambitions. If science educators wish to succeed in fostering desirable skills, values and attitudes, then experiences with science should begin at as early a level as elementary school. The Science Council of Canada lists four major reasons for the necessity of reform and "Science for All":

(i) To develop informed citizens capable of decision making

(ii) To train those interested in pursuing careers in science and technology

(iii) To prepare for a work world constantly being changed by technology

(iv) To facilitate intellectual and moral growth

(i) Development of Informed Citizens

The understanding of the interaction between science, technology and society is necessary for all citizens of a democratic society. Equipped with the proper know-how, one is able to participate and exercise control in the decision-making process. A well-informed electorate can profoundly influence the social will. If the application of technology needs to be restrained to avoid its undesirable effects on society, then science education should be available at all levels of schooling to produce informed citizens.

(ii) Training for Employment

Science education, comprised of science, mathematics and technology,is the right and need of all children living in a technological society. As a consequence of technological advancement, the work place is using more highly specialized equipment. Rapid technological changes demand skilled and trained workers, since future generations depend on scientific and technological skills for their employment. Science education should, therefore, provide opportunities for all children to learn scientific and technological skills.

(iii) Preparation for Further Education

Preparation for higher education has always been the major aim of science education at the lower levels. Emphasis, however, was mainly placed on the learning of abstract principles. The processes of science, if and when employed, were of a rudimentary nature. The "Science For All" aim advocates the experience of real science, as it relates to the personal experiences of learners. This provides better incentives and motivation for life-long learning. Teaching science in an interdisciplinary context is also the demand of changing times. In its survey, the Science Council of Canada has received many responses favoring an interdisciplinary approach to science--many of which propose the co-ordination of science and math education.

(iv) Science for Intellectual and Moral Growth

Science education, like any other discipline, has always aimed to contribute towards the development of the child beyond school age. However, emphasis was mostly placed on the knowledge acquisition aspect of intellectual development, while the component of intellectual skill development was often ignored. Inquiry skills were used to imitate scientists and not to solve the real problems as scientists do. Children are already engaged in the process of

> understanding the world around them and will develop their own explanations of it. Science education, fostering scientific knowledge and its processes, should therefore guide and nurture children's natural curiosity and intellectual growth. The importance of such a science education has been described by the cognitive development studies of Jean Piaget and David Ausubel (Smith, 1984).

Scientific Literacy

An encompassing goal proposed by reform initiatives in the late eighties was the acquisition of scientific literacy by all school children. One aspect of scientific literacy is based on the knowledge of principles, processes and skills in science, mathematics and technology. The other dimension includes an understanding of the relationship between technology and society, and how they affect one another. For instance, society benefits from many technical tools used in industry, medicine and the household. On the other hand, technological advancements deplete natural resources and pollute the environment. The survival of mankind and this planet depends on the wise use of science and technology; hence, the need for scientific literacy in the biophysical environment, in social behavior, and in the use and misuse of technology. A scientifically literate person is defined as:

> One who is aware that science, mathematics and technology are interdependent human enterprises with strengths and limitations; understands key concepts and principles of science; is familiar with the natural world and recognizes both its diversity and unity; and uses scientific knowledge and scientific ways of thinking for individual and social purposes.
>
> (Project 2061 1989, p.4)

The major components of scientific literacy that emerge from the aforementioned definition, when categorized, should appear as follows:

(i)	Awareness:	Sensitivity to science- and technology-related problems
(ii)	Knowledge:	Understanding of the fundamentals of science and technology disciplines necessary to study the problems
(iii)	Skill:	Problem-solving, communication and critical thinking skills required in finding solutions to science-society-technology related issues
(iv)	Attitudes:	Feelings of concern for the natural world, motivating the learner protect and improve its unity and survival
(v)	Participation:	Active involvement in social decision-making and personal responsibility for science-technology-society related issues

Teaching-Learning

If science education is expected to fulfill its new role, then teaching-learning also needs to be changed. Both Canadian and U.S. reform initiatives recognize the role of instruction in effective teaching-learning. Teaching-learning

depends, however, on many factors, such as the ones listed below:

(i) Material to be learned

"Science For All" puts more emphasis on the understanding aspect than on the quantity of information presented, therefore the selection of the most important and relevant concepts and of attainable tasks becomes mandatory.

(ii) Previous knowledge of the learner

Previous knowledge about science is also a factor that affects the learner's understanding. To facilitate its accommodation, new information needs to be presented in a variety of ways.

(iii) Teacher's Background

The professional growth of the teacher is vital for effective science education. At the elementary level there is a great need for pre-service and in-service training. It is necessary to compensate for deficiencies in the teacher's scientific background. Secondary teachers, although carrying university degrees, require professional growth and development, especially in new technology and methods.

(iv) Physical Conditions

Laboratory facilities are a must for teaching science. Most high schools having labs would still require some revamping of equipment and material.

Elementary science education, however, requires enormous changes to provide for well-equipped labs. The Canadian initiative also points out the necessity of access to computers and video technology at both the elementary and secondary levels, so that students may experience the impact of science and technology firsthand.

Teaching science along technological and societal lines, and in the context of problem-solving and decision-making, requires new instructional approaches that employ both "instruction" and "training". Instruction facilitates the incorporation of knowledge, while training helps students acquire the skills necessary for scientific operations. Awareness and possession of skills, therefore, are the keys to making responsible decisions. The quality of a teaching method depends on the presence of both instruction and training components. Lack of either of these components renders it less suitable for a truly liberal education.

With the increase of computers in Canadian schools, the Science Council of Canada recommends the use of new teaching approaches such as simulations (Smith 1984, p.61). However, the council advises teachers to use nationally-produced software, because it is economical and also prevents the export of Canadian educational decision-making (Smith, 1984).

Simulations and games are among the new approaches to teaching-learning. Their use is quite common in social and management science, although science education has been relatively slow in adopting them. The importance of simulations and games for science education becomes evident when one compares the past, present and future of science education. As Bybee says:

> In the past, the textbook was the curriculum, at present, the textbook and laboratory are the curriculum, in the future, the textbook, laboratory, simulations, games, community experiences, electronic media and other informal educational resources will be the curriculum. (Emphasis added)
>
> (Bybee, 1982, p. 344)

This Monograph also proposes the use of simulations and games for teaching science. However, this paper will deal with the use of simulations and games in the context of the Quebec Ecology and the Human Biology Curricula.

2. Purpose of the Study

This monograph proposes the use of a relatively new instructional strategy namely, the simulation and gaming method of teaching Science. For this purpose, two science disciplines have been chosen:

(i) Secondary I: Ecology

(ii) Secondary III: Human Biology

The aim of the present study is to:

(1) Identify the content in the present Quebec Curriculum of Ecology (Secondary I) and Human Biology (Secondary III)that is taught using certain teaching-learning strategies as well as simulations and/or games.

(2) Isolate those concepts in each of these Quebec curricula, for which there exist a simulation and/or game.

(3) Present each of these concepts in the same order as they appear in the Quebec curriculum and match them with the simulations and/or games considered suitable for teaching.

In order to achieve this goal, an attempt will be made to:

(a) Describe the objectives mentioned in the Quebec curriculum for the teaching of these concepts.

(b) Select a simulation and/or game believed to enhance, supplement or provide a better substitute for the existing teaching-learning methods.

(c) Justify the selection of those simulations and/or games for the teaching of these concepts.

(d) Describe the generally known benfits of the simulations and gaming method of teaching.

(e) Include some recommendations for the use of simulation and gaming approah to teaching.

CHAPTER II

SIMULATIONS AND GAMES FOR QUEBEC'S ECOLOGY AND HUMAN BIOLOGY PROGRAMS

CHAPTER II

Simulations and Games for Ecology and Human Biology Programs in Quebec Secondary Schools

1. Introduction

The need for scientific literacy requires that students understand the relevance of science learning to themselves and to society. For such an understanding to occur, the learning process needs to be interesting. Teachers should therefore be in search of new teaching aids that can make teaching-learning exciting and challenging.

Simulations and games are among the new teaching tools that are gaining momentum in science teaching. Biological sciences are no exception nevertheless, the incorporation of simulations and games as a viable teaching aid, depends on their availability and content relatedness.

An attempt was made to explore the existence of simulations and games suitable for the Quebec Ecology and Human Biology Curricula. This search has yielded an encouraging number of ecology- and human biology-related simulations and games.

Chapter II presents an account of the simulations and games considered suitable for teaching two of Quebec's secondary school Curricula:

1. Ecology
2. Human Biology

It is hoped that these simulations and games will help teachers who are searching for new instructional strategies.

CHAPTER II

SECTION A: ECOLOGY

The Ecology Curriculum of Quebec secondary schools is comprised of six modules: Ecology, Interrelationships, Functions of Producers, Functions of Consumers, Circulation of Matter and Energy, and Environmental Influence on Living Organisms. Each module in turn consists of many sections. The number of sections varies from module to module. All sections carry a terminal objective and a variable number of immediate or specific objectives. The Ecology Curriculum also mentions learning content for both terminal and immediate objectives.

For the purpose of this study, which proposes the utilization of simulations and games, four criteria were derived based on the course content that is identified in the Quebec Ecology Curriculum and Curriculum Guide. They were used either singly or in a combination of two or more:

(1) **Terminal objectives**

(2) **Immediate or specific objectives**

(3) **Learning content prescribed for terminal or immediate objectives**

(4) **Content-related activities forming part of the curriculum guide.**

The present research has yielded approximately twenty-one ecology-related simulations and games. These are listed in Appendix B. This collection contains both computer and non-computer simulations and games that will help in the assimilation of many ecological concepts. The simulations and games were grouped under the following seven ecological topics:

1. Characteristics of Living and Non-living Things
2. Predation
3. Natural Resources
4. Pollution
5. Plants
6. Food Chains
7. Population

For most of the aforementioned topics, more than one simulation or game was found. In two cases, however, only one simulation or game per concept was found. Following is an account of these simulations and games.

Simulations and Games for Teaching Secondary I: Ecological Concepts

This section attempts to justify the suitability of selected simulations and games in teaching specific ecological concepts. Therefore, the objectives and teaching strategies

for each concept will be described first, as they appear in the Quebec Ecology Curriculum. Appendix D contains excerpts from the Quebec Ecology Curriculum Document with circled areas denoting the sources of the concepts that were identified.

1. CHARACTERISTICS OF LIVING AND NON-LIVING THINGS

a) Objectives and Teaching Strategies

The terminal and immediate objectives require that the learner be able to (i) identify the living part of the environment, (ii) name the characteristics of a living organism, such as movement, feeding, growth, reproduction and respiration, (iii) distinguish between living and non-living things, and (iv) classify at least twenty given things into living and non-living categories (Ecology Curriculum, p. 20).

The Ecology Curriculum Guide (p.49) suggests three possible ways to teach this concept: field investigation, guided class discussion and worksheet activity. Field investigation is no doubt the best way to learn this concept; however, very few teachers these days opt for field studies. Instead, they commonly choose guided class discussion and the use of worksheets.

b) Simulations and Games

This study has revealed only one game for teaching the concept of living and non-living things:

LIVING OR NON-LIVING--A Game of Twenty Questions

This is a simple game devised by two Michigan State University professors, Wilson and Mullins (1980). They point out two important facts: (i) intuitively students know whether a thing is living or not, (ii) in practice, students are unable to tell what separates living from non-living.

Wilson and Mullins also realize that the commonly taught characteristics of living things (i.e. movement, growth, reproduction and respiration) as presently defined, tend to confuse students, since movement, growth and the production of wastes also apply to some non-living things. For instance, machines of all kinds move, and automobiles even produce wastes. Conversely, some living things do not possess these traits. For example, adult organisms do not exhibit growth and neutered pets do not reproduce. The authors believe that their game facilitates an understanding of the traits of living things.

In the game, some students have to pretend they are a "thing" from another planet. By answering questions, their peers decide whether the "thing" is living or non-living. Ultimately, students develop a definition of a living system. Therefore, the game helps students understand that living things are part of a process, in conjunction with their environment. The use of traits per se to distinguish between living and non-living things is de-emphasized.

c) Rationale for Selection

This game is a good substitute for guided class discussion and worksheet activities.

2. PREDATION

a) Objectives and Teaching Strategies

Curriculum objectives require students to (i) illustrate some phenomena of predation and (ii) distinguish between prey and predator (Ecology Curriculum, p.22).

Teaching strategies proposed include guided class discussion, research, written or oral reports and worksheet activity (Curriculum guide, pp. 91-93).

b) Simulations and Games

For the concept of predation one card game and one computer game-simulation were found and are presented here:

(i) PREDATOR-PREY: A Card/Board Game

This is a card and board game involving chance factors but no decision making. It was designed by Collins and Katona (1970) to facilitate an understanding of the predator-prey relationship. Animals are represented by "animal-cards" of which each player begins with an equal number. Students also learn about the population ratios of many animal species and the importance of maintaining an ecological balance. One attractive feature is that the role of predator is extended even to man, who also poses a threat to animals.

(ii) SHARK: A Computer Gaming Simulation

This is a computer gaming simulation developed by a biologist at Clemson University, South Carolina (Kosinski, 1989). It involves the predatory activities of a Bonnethead shark searching for its prey in coastal waters. Successful tracking depends on the sufficient reception of smell, sound and electrical signals from the prey. Players gain points by correctly steering the Bonnethead down the signal gradients to its prey. In doing so, learners require a knowledge of the signals and habitats of different prey species. A non-visual "instrument panel" helps record these signals. Whereas a user's manual provides habitat information on approximately forty prey species, players have to solve another problem--they must protect the Bonnethead from the attacks of large off-shore dwellers like the Sandbar and Tiger sharks.

Technical Data: Apple II or IBM/PC. Disk, instructor's manual and student exercises.

c) Rationale for Selection

Both the card/board game and the computer simulation's "instrument panel" provide the opportunity for experiential learning. With the help of these tools, predator-prey interactions should be much easier for students to understand. Class discussions, worksheet activity and research reports, although better than lecture techniques, do not, however, provide a superior substitute for experiential learning.

3. NATURAL RESOURCES

a) Objectives and Teaching Strategies

In the Ecology Curriculum Documents, natural resources are mentioned in connection with two objectives (p.24). One of these (Terminal objective #I.II) relates to the beneficial use of natural resources, while the other (Terminal objective #I.12) is concerned with the risks involved in the detrimental use of these resources.

Teaching strategies for promoting motivation in the acquisition and performance activities include audio-visual presentation, guided class discussion, research, community-based projects and field investigation.

b) Simulations and Games

The search for simulations and games related to the concept of natural resources yielded one game and one simulation which are described as follows:

(i) ECOLOGY: The Game of Man and Nature

This is a card and board game developed by Collins, Rosen and Peret (1970) that conveys two main messages: (i) the need for protection of natural resources and (ii) the need for monitoring of technological advancements in order to maintain ecological balance.

The players begin the game with equal resources. Each one acts as a leader of populations of men who compete to win.

The idea of maintaining an ecological balance is central to the game's theme. It requires strategic thinking and compromising to arrive at decisions. Chance also plays an important role since movement around the board is determined by the throw of the dice. Repeating the game is a good way to learn to try different strategies for achieving ecological balance. This game is suitable for both individual and team playing.

(ii) NO DAM ACTION: An Ecology-Water Resource Simulation

This is an interactive simulation produced by Klietsch (1970) that can be played by individuals or in teams. Its emphasis is that resources are in limited supply, and that their use requires wise management and policies. Students are thus taught that the socio-political aspect of environmental control plays an important role in decision-making. The playing action revolves around water resource management for a given area. Effective management requires planning, prediction, communication, group skills, measurements and compromise. Players begin with differing resources and act out their assigned roles as county residents, officials, business people and special interest groups.

This simulation provides eighteen problems ranging from recreational use of water to water purification standards. It makes players aware of the consequences of their actions as resource managers. Moreover, it is a very good simulation of

conflict of interests in water resource planning and utilization. The materials include a player's and administrator's manual, role cards, playing forms, as well as group and problem information. Field test results are also available.

c) Rationale for Selection

The community project and survey methods, as prescribed by the Quebec Ecology Curriculum Guide (pp. 114-115), provide information about real-life action taken by others. However, these methods fall short of providing the student with an opportunity to experience decision-making per se. Therefore, it is believed that the simulation and game presented here would supplement the project and survey methods suggested in the Ecology Curriculum Guide by providing experiential learning about the use and abuse of natural resources and the consequences.

4. POLLUTION

a) Objectives and Teaching Strategies

Objectives for understanding pollution are listed in two different sections in the Ecology Curriculum. The first section starting on page 22 identifies the basic differentiation between "natural" and "polluted" states of air and water (Terminal objectives #1.4.1 and 1.4.3) and toxic substances (Terminal objective #1.4.5) responsible for

pollution. The other section (p.24) investigates the dangers of using polluted air, water and soil (Terminal Objective #1.12). To control pollution, the curriculum proposes "recycling" (p.39). It is to be noted that this concept is introduced later in the fourth module entitled "Circulation of Matter and Energy". The study of recycling aims to familiarize students with: (i) the mechanism of recycling wastes (solid and/or liquid) and organic matter, and (ii) the sources of energy waste in the form of heat.

Strategies for teaching about pollution include guided class discussion, community projects and surveys (Curriculum Guide pp. 106-115). However, no teaching method is specified for the teaching of recycling.

b) Simulations/Games

Of the large variety of simulations and games that exist on pollution, eight were selected to be included in the present study.

(i) AIR POLLUTION

This is a computer simulation produced by Chandler (1986). It deals with the air pollution in a hypothetical city--the main cause being automobile emissions. Students can select wind-speed, number of vehicles on the road, emission rate and average traffic speed. The computer displays carbon dioxide levels in a tabular or graphic form.

Technical Data: Apple II, 48K; TRS-80 Models I, III and IV.

(ii) DIRTY WATER

This is a card and board game, developed by Anderson and Trilling (1970 a), for individual play. The player becomes the city administrator of water quality, and makes decisions about water pollution for the city's population. He/she is responsible for maintaining an ecologically balanced lake, controlling pollution and preventing over-population. Students learn about water ecology, as well as the problems associated with water pollution and decision-making. Pre-tests and post-tests are also available.

(iii) POLLUTION

Another card and board game for team play was introduced by Clark Abt Associates (1970). It requires the co-operation of players who role-play as small business, industry and local government to run a polluted and an unpolluted town. Decision-making, coalition formation and strategic thinking is needed for purchasing pollution control devices.

(iv) POLLUTION GAME

This is a card and board game produced by Rasmussen (1970) for individual and team playing. Although competing, players also must co-operate, in that the game teaches strategic thinking, bargaining, coalition-formation,

compromise and political decision-making skills. Field test results are also available from the Educational Research Council of America in Cleveland, Ohio (Haughton Miffin Company, 1970).

The game begins with rolling the dice to determine who will own which group of properties. The value of properties differs--some even increase in value as the pollution index augments. The winner is the one who gains the most money at the end of the game while trying to keep air and water pollution at low levels. Everyone loses, however, when the pollution index exceeds the lethal level. Therefore, all players must co-operate or the game will end due to excessive pollution. Three features are especially attractive in this game: (i) it involves interdisciplinary knowledge in ecology, biology, political science and urban studies, (ii) it teaches the economics of pollution as well as politics and economics for saving the environment, and (iii) it allows players to modify the rules and make their own proposals when they play it a second time around.

(v) RECYCLING LOGIC: A Computer Game

"Recycling Logic" is an interactive computer game created by Sunburst Communications (1988). It permits players to decide which of the garbage cans should go to a recycling centre. Some contain paper and metal; others organic or paper garbage. Students choose either, neither or both garbage cans depending on their interpretation of the clues about garbage

contents. Winning depends on the rational guesses and logical conclusions that the students make while working with words such as "and, or, not, either, if...then", etc.

There are two levels of difficulty: easy and advanced. At the easy level, two statements are made which are true, while at the advanced, students work with "If...then" strategies. In solving the problem, help is available but players neither gain nor lose points. When a wrong garbage can is chosen, the computer displays statements which help learners rethink the problem. This game provides quite a challenge since over 6000 combinations are available in its data base. The package also contains worksheets and suggestions for many other activities.

Technical Data: Apple Series. Disk, back-up and manual.

(vi) SACRIFICE

This is an interactive simulation developed by EVI Staff (1971) that requires the co-operative efforts of individuals in a team. It involves strategic thinking, role playing, coalition-formation, bargaining and compromising. Oral communication skills are an asset. Roles include individuals working in many interest groups, business and governmental agencies and in utility companies.

Players start with equal resources but their roles limit their options. Cards with decision options are dealt at random, therefore chance is involved. Players make decisions

on certain courses of action regarding pollution problems, and consult among themselves under a time limit. The message is that everyone has to make some sacrifices to solve environmental problems.

This simulation teaches that there is no simple solution to ecological problems and that the simple clean-up notion is not realistic. Pre-tests and post-tests are available.

(vii) SMOG

This is an interactive card-board game developed by Anderson and Trilling (1970 b) that teaches skills, decision-making and strategic thinking. Players assume the role of a planning manager of a city who has to maintain a balance between municipal growth and the quality of city air. The package contains pre-tests and post-tests.

(viii) WATER POLLUTION

This is a computer simulation invented by Harmon (1986) which permits the user to apply many variables. Students can adjust the water temperature, the type of waste, the method of waste treatment, the dumping rate and some other variables for a given body of water. The computer reports oxygen and waste levels of water in graphic and tabular form.

c) Rationale for Selection

Compared to the teaching methods suggested in the Ecology Curriculum Guide (pp. 114-115), the simulations and games

presented here appear to be a superior tool for teaching-learning topics about pollution, because they provide a chance for experiential learning. The other major benefits include acquiring the skills of problem-solving, decision-making and communication. Therefore, it is believed that these simulations provide a better alternative for the study of pollution and recycling concepts than current classroom strategies which are more limiting in scope and less motivational and challenging.

The game on recycling is very effective in developing reading comprehension, reasoning and critical thinking skills, since students work with "and, or, not, either, if...then" strategies and interpret clues. This game also facilitates the understanding and importance of recycling. An added advantage is that students learn to distinguish between reusable material and non-reusuable material. It is very important for students to know that the present state of recycling technology is limited in its application.

5. PLANTS

In the Quebec Ecology Curriculum, the general objective of the second module entitled "Functions of Producers" is to learn about the plant as an organism (Ecology Curriculum, p.25). There are ten sections in this second module which deal with different aspects of plants. For the purpose of the

present study, the following are of interest:

(i) Growth requirements

(ii) The role of leaves

(iii) Cell processes

(iv) Plant competition

In discussing each of these concepts, the objectives and teaching strategies will be described as they are specified in the Quebec Ecology Curriculum. An account of the simulations or games considered useful for the teaching-learning of plant processes will follow.

i. Growth Requirements

a) Objectives and Teaching Strategies

Based on the Ecology Curriculum (p.25), the growth requirement objectives in the course necessitate that students learn to identify the non-living elements essential for the process of assimilation in plants. This translates into explaining the importance of water, light, carbon dioxide and mineral salts, such as nitrate fertilizers in plant growth. Lab demonstrations are recommended for the study of these growth requirements and for developing a better understanding of the process (Ecology Curriculum Guide, pp.133-139).

b) Simulations/Games

Under the Growth Requirement topic, only one simulation will be presented as follows:

Computer Investigation: PLANTGROWTH

This software, developed by Focus Media (1989), is a computer simulation which allows students to grow corn plants. The option exists for students to select and control many variables--light conditions, day length, carbon dioxide, nitrates, pH and temperature--for up to eighteen weeks. They can observe the effects of one or more variables chosen at two-week intervals and from the program's library, students also learn how all the variables affect the corn plant. Learners try to achieve the best growth and to win various levels of "Green-thumb" awards.

This simulation offers a chance for students to design experiments by altering one variable at a time. They also learn data interpretation from the graphs they plot. It is a good simulation for individualized work.

Technical Data: Apple Series. Disk, back-up, teacher's manual and student workbook.

c) Rationale for Selection

The laboratory demonstrations suggested in the Ecology Curriculum Guide are good teaching strategies; however, laboratory investigations are generally cumbersome and time consuming. The "PLANTGROWTH" simulation offers an excellent way to condense eighteen weeks of plant growth experiments into a relatively short time, without the worries of becoming involved in experimental procedures or of experiencing the

failure of some of the plant growth.

ii. Role of Leaves

a) Objectives and Teaching Strategies

The major objective here is to explain the role of leaves in the growing cycle of a plant, especially in the processes of photosynthesis and transpiration. The Ecology Curriculum Guide (pp. 158-160) recommends the use of guided class discussion, the research report and work-sheet activities to study the functions of different parts of a tree.

b) Simulations and Games

For the study of the role of leaves in plant life, one simulation entitled "Transpiration" will be presented:

TRANSPIRATION: A Computer Simulation

This simulation, produced by Longman Microsoftware, is designed to complement investigations with real plants. It simulates stomatal movements and transpiration (water loss by leaves), and also permits investigations into the effect of environmental factors on transpiration. The unit increases in complexity and thus can be used at various levels of schooling.

Technical Data: Apple II Series. Disk, back-up and manual.

c) Rationale for Selection

Stomatal movements are difficult to observe in high school lab facilities. Therefore, the simulation of stomatal opening and closing alone makes this software an attractive tool in learning the phenomenon. In most high school lab investigations the accumulation of condensation on the wall of the jar covering the plant is taken as a sign of the occurance of transpiration.

In the simulation, the loss of water from the leaves is depicted as in the real event, thus creating excitement among the learners which further enhances their understanding of the process. Compared to the suggested teaching strategies in the Curriculum Guide, this simulation is a better learning tool for the observation and comprehension of transpiration.

iii. Cell Processes

a) Objectives and Teaching Strategies

Cell processes are carried out in different parts of the plant and are responsible for its growth cycle. The curriculum objective, therefore, is to study the role of different parts of the plant in maintaining this cycle. The curriculum makes no mention of teaching or learning activities.

b) Simulations and Games

The software being presented here, contains three programs

which facilitate the study of many plant processes:

DESIGNING BLUE PRINTS FOR GREEN PLANTS: A Computer Simulation

This computer simulation, developed by Heath and Co. (1989), allows for the exploration of the relationship between the structure and functioning of plant tissues. It also reveals the environmental affects on the design of a plant and the workings of various tissues in unison for the survival of plants. The simulation package contains three student programs and a guide for the teacher. Each student program has its own title. The titles and descriptions of the programs are as follows:

(i) Notes and Results

This software package provides information needed to design a plant. Eight processes are described: absorption, gas-exchange, growth, photosynthesis, protection, storage, support and transport of material. Learning activities include an exploration of the characteristics of tissues and their relationship with each other. This software also lists the characteristics of six biomes, as well as describing the limiting factors that determine a plant's survival.

(ii) Make it Work

In this program students correct the flaws in the design of a plant using information from the "Notes

and Results" section. Students can redesign a plant by moving tissues in the plant around and replacing them. The computer tests the new plant design and determines if the plant can survive.

(iii) Plant Design

This program permits students to create a biome-specific plant from scratch. After the completion of a plant design, the computer gives the plant structure, liquid, gas and energy, as well as tests to check if the plant can survive in the biome the student has chosen.

"Management System" software records the work of approximately thirty students and even saves and prints out the student's plant design.

Technical Data: Apple II Series. Disk and teacher's guide.

c) Rationale for Selection

DESIGNING BLUE PRINTS FOR GREEN PLANTS is by far the best simulation on the structural design of a plant. It uniquely provides an understanding of the interrelationship that exists between structural design and the survival of a plant in a given plant environment. By designing or creating a new plant structure, students learn what flaws exist and how these can be corrected to assure the survival of a plant. Students also learn the advantages and disadvantages of certain

structures in relation to the plant's environment. In this way, the student is really learning by doing. However, the experience, in the case of designing a plant, is not possible in the lab or in field conditions for high school students. Only computer simulations can help explore these aspects of plant study. This simulation is useful in the teaching of ecology, biology of plants, horticulture and agriculture.

iv. Plant Competition

a) Objectives and Teaching Strategies

The curriculum objective is to learn the principles which determine a plant's use of time and space (Ecology Curriculum, p.27). Teaching strategies include audiovisual presentation, research and project reports (Curriculum Guide, pp. 166-167).

b) Simulations and Games

Two computer simulations which facilitate the comprehension of the phenomenon of competition among plants will be described here:

(i) COMPETE: A Computer Simulation

This is a software package developed by Leveridge (1983) which allows the students to study the competitive growth of plants in single and mixed cultures. Students can also study the effects of crowding and plant interaction below the ground. The computer makes a graph of the changing plant mass against time.

Technical Data: Apple II, 48K. Disk and manual.

(ii) SEEDLING: A Computer Simulation

Developed by Kosinski (1989), this simulation also concerns plant competition and plant physiology. It permits the study of a crop plant in three different environmental conditions:

(1) Moist temperate

(2) Wet tropical

(3) Growth chamber with controlled conditions

Three growth chamber experiments are possible:

(a) Effects of decreasing the distance between plants

(b) Plant response to variable temperature and light conditions

(c) Effects of temperature and humidity on transpiration

Technical Data: Apple IIe or IBM/PC. Disk, instructor's manual and student exercises.

c) Rationale for Selection

Plant growth experiments in the laboratory are time-consuming in yielding results, whereas computer simulations save time and make it easier to manipulate and combine variables for the study of their effects. They enhance the understanding of plant competition and interaction without the help of lab experiments.

6. FOOD CHAINS

a) Objectives and Teaching Strategies

The main objective in learning about food chains is to be able to identify the following on a diagram showing a food chain of a terrestrial environment: producers, herbivores, carnivores and decomposers and their links (Ecology Curriculum, p. 38). The teaching strategy employs the use of diagrams which are considered to be the learning model for the memorization of the concept (Curriculum Guide, p. 191).

b) Simulations and Games

One computer simulation was found for this section:

ODELL-LAKE: A Computer Simulation

This computer simulation was created by Ken Witte of Tracy Minnesota School and deals with the concept of food chains and predator-prey relationships in a lake ecosystem. It requires that students assume the role of a fish within a fish food chain in Odell lake, located in the Cascade Mountain Range in Oregon state. The objectives of this simulation are to make students:

(1) Understand the food relationship (predator-prey) within the fish food-chain

(2) Simulate the life of a fish and make survival decisions

(3) Generalize the size relationship between fish

(4) Create an awareness of the plant and animal life forms found in water

In the role of a fish, students encounter large birds, mammals, insects and other fish. These encounters demand that, as a fish, they make decisions whether to:

(a) Escape to deeper waters

(b) Escape to shallow waters

(c) Attack and attempt to prey

(d) Attempt to chase the intruder out of the territory

(e) Ignore the encounter

The package also includes follow-up activities, students' worksheets and follow-up questions.

Technical Data: Apple Series. Disk, back-up.

NEW VERSION OF ODELL LAKE: Students will enjoy working long hours on the modified version of Odell Lake (Conrad, 1988). Graphics were added for the Apple IIe version by the Minnesota Educational Computing Consortium (MECC) staff. The first section starts with a menu that explains how to play, score and fish in Odell Lake. In the second section (as in the old version) students play the role of fish in the lake and learn about food chains and predator-prey relationships through a decision-making approach. Correct decisions are rewarded and incorrect decisions elicit a reminder of fish inter-relationships.

This program also provides information about scientific names, weight, length, habitat and special comments about many fish species. The third section is timed and enables students

to score points by making correct decisions about different organisms they encounter. The time is shown by a bar at the bottom of the screen, while the score is displayed at the top. The new version also features an additional attraction--a teacher's manual, which provides material for a variety of instructional settings.

c) Rationale for Selection

The Odell Lake simulation provides an excellent alternative method for teaching-learning food chains and predator-prey relationships. This understanding is achieved through role playing and a decision-making approach. This simulation is very suitable for learning the actions of a prey confronted by a predator and the actions of a predator pursuing its prey (Terminal objective #5.6.6 and 5.6.6, p.45).

7. POPULATION

a) Objectives and Teaching Strategies

In the Quebec Ecology Curriculum the primary objective of the population study is to explain population fluctuations at a given time by using a table depicting the predator-prey relationship. Immediate objectives include:

(i) Determining population density by using the formula: D=N/S; that is, Density = No. of individuals/ Space occupied by these individuals

(ii) Determining the number of individuals in a population sample using the formula: N = D x S

(iii) Defining carrying capacity

(iv) Explaining the consequences of too large a population in a limited space (Ecology Curriculum, p.40)

Teaching-learning aids are diagrams and tables with codes and symbols which help students to derive coherent explanations (Curriculum Guide, p.192).

b) Simulations and Games

Two computer simulations are presented here. The first one, called "Plankton", deals with optimum conditions for population growth. The second, on field ecology, emphasizes the importance of predators for the control of prey population.

(i) PLANKTON

This program, created by Kosinski (1989), simulates lake phytoplankton ecology. The game component allows students to control the phytoplankton population--students can move around phytoplankters to various depths of water, searching for optimum population growth conditions. Two experiments are available. One permits the manipulation of variables, such as temperature, light, nutrients and grazing pressure, which help in determining the limiting factor for population growth. The other facilitates a study of the synergistic effects of two or

more limiting factors.

Technical Data: Apple IIe or IBM/PC. Disk, instructor's manual and student exercises.

c) Rationale for Selection

This simulation provides a better alternative for population studies than the recommended diagrams and table method. Moreover, it gives students opportunity to study population growth and limiting factor synergism in a short time period. As is well known hands-on activity in field and laboratory investigations is time consuming and cumbersome. It should also be noted that, for this reason, in ecological studies, computer simulations rank high for studying population.

(ii) THAT'S LIFE: FIELD ECOLOGY SIMULATION

This simulation, developed by Mindscape (1989 a), puts students in the position of an island's deer-herd manager. Deer-herd control is necessary in protecting the island's pastures, and management demands the removal of deer from the area, or the introduction of predators, such as wolves or mountain lions. Four different habitat options are given: swamp, forest, shrubland and grassland. Therefore, before applying the herd management procedures, students must research plant and animal life, check the deers' health and survey the predator population. This program comes with

information documents, however, students should have prior knowledge of food chains, carrying capacity and methods of surveying population. Data can be saved only after completing the program.

Technical Data: Apple IIe/c, color monitor. Disk, back-up and guide book.

c) Rationale for Selection

This simulation is very appropriate in grasping the concept of "carrying capacity" and for learning about the consequences of population growth of a given species beyond the carrying capacity of its habitat. In fact, it provides for and facilitates the learning of all terminal and immediate objectives that pertain to population studies (Ecology Curriculum, p.40).

CHAPTER II

SECTION B: HUMAN BIOLOGY

The Quebec Human Biology Curriculum, a mandatory course for all students at the Secondary III level, is based on three modules: Nutrition, Relationships, and Reproduction. Each of these modules is comprised of a number of units. There are six units in the Nutrition module, whereas the Relationships and Reproduction modules each have two units. For all modules and units, terminal objectives are listed. Units carry an additional objective termed "Immediate Objective" and content related to this objective is also specified.

The Quebec Human Biology Curriculum (Appendix E) and its Curriculum Guide (Appendix F) served as the criteria for our selection of simulations and games. Based on the content of these two documents, four specifics were used to determine the simulations and games that would be suitable for use by teachers and their students. These four categories of identified specifics are listed below:

(i) Title of the section of a module

(ii) Intermediate objective(s) of the section

(iii) Content related to intermediate objectives

(iv) Learning content as specified in the Curriculum Guide

A simulation or game was selected if any one, or a combination of the aforementioned Human Biology Curriculum specifics, justified its inclusion. In all, twenty-four simulations and games were selected. Both computer and non-computer simulations and games form a part of this inventory, which was then arranged under seven major headings (refer to Appendix C):

1. Cardiovascular system
2. Digestion
3. Locomotor system
4. Nervous system
5. Reproductive system
6. Sense organs
7. Human body

Simulations and games specific to a system or an organ of that system are listed under one of the six major systems of the human body. However, those which pertain to more than one organ or system are simply grouped under the general heading of "Human body".

Analysis of Simulations and Games Selection

In this section, a brief analysis of selecting a simulation or game for a particular concept in the Human Biology Curriculum is presented. First of all, for each concept, mention of its objectives and prescribed teaching-

learning strategies is made. Then, the inclusion of a simulation or game is suggested which is believed to enhance or supplement the treatment of the topic. A brief description of each simulation and game is also given to justify its suitability as a learning aid.

The concepts for which simulations or games are selected are dealt with in the same order as they appear in the Quebec Human Biology Curriculum document. Appendix E contains excerpts from this document which will henceforth be referred to as "HB-Curriculum" for page referencing purposes. The points of interest on these pages will also be circled for easy reference.

1. CARDIOVASCULAR SYSTEM

A. Objectives and Teaching Strategies

The cardiovascular system forms the third unit of the "Nutrition Module" and is entitled, "The Transportation of Selected Intake". It deals with the nature of the circulatory system and its importance. Unit Three is comprised of three sections (HB-Curriculum, pp.19-21):

1. Anatomy of the Circulatory System
2. Physiology of the Circulatory System
3. Cardiovascular Hygiene

A brief account of the terminal objective, intermediate objective and teaching-learning activities is in order to

understand the teaching of this unit of the human biology program.

1. Anatomy of the Circulatory System

The major objective of this section is to study the main components of the circulatory system and their relationships to blood circulation. Twelve intermediate objectives (HB-Curriculum Guide, pp.19-20) translate into knowledge acquistion of the (i) structure of the heart, (ii) blood vessels, (iii) composition of blood and the function of its components (i.e. plasma and blood cells).

Learning strategy prescribed includes drawings, diagrams and cuttings. Use of the microscope to observe blood circulation in living animals such as frogs and goldfish is also recommended (HB-Curriculum Guide, pp.48-49).

2. Physiology of the Circulatory System

The main objective related to this section states the relationship between certain anatomical structures of this system and their physiology. This covers three phenomena: (i) vaccination, (ii) blood groups, and (iii) capillary circulation. Therefore, specific objectives (HB-Curriculum Guide, p.20) emphasize the learning of antigen, antibody and immunization as well as substance exchange in the capillaries.

Learning activities mentioned in the HB-Curriculum Guide (p.520) include projects on epidemics which emphasize the importance of vaccination. Lab experiments on osmosis and

diffusion that relate to the capillary exchange of substances are also suggested (HB-Curriculum Guide, p.52).

3. Cardiovascular Hygiene

This section is aimed at the health problems associated with the cardiovascular system and their prevention. A summary of intermediate objectives points to the study of (i) relation of lifestyle to heart and blood vessel complications and (ii) dangers and symptoms of high blood pressure.

Learning activities mainly require simple observations, such as (i) listening to the heartbeat through a stethoscope, (ii) taking blood pressure at different levels of physical activity and (iii) feeling the pulse at different points of one's body. Based on the data of these aforementioned observations, comparisons can be made and relationships established (HB-Curriculum Guide, p.54).

B. Simulations and Games

Simulations and games collected for the cardiovascular system section reveal an enormous amount of learning-content coverage. Computer software often contains more than one program on different aspects of the circulatory system. Consequently, the overlapping of concepts is common. Therefore, simulations and games pertaining to the cardiovascular system are discussed under their own title. Concepts covered here are mentioned in the description of each simulation and/or game. A total of eight were selected as follows:

(i) HEART PROBE

(a) Description of Simulations/Games

This is a computer simulation and game combination developed by Bio-Soft (1989). The simulation component is an animated program that deals with the internal structure of the heart, heartbeat and blood flow. Two features of this program are most innovative: (i) it requires students to operate on the heart through a learner-controlled probe, and (ii) an animated lesson depicts heartbeat and blood flow. After the operation on the heart, the learner is also given a chance to test his/her mastery of the information through an on-screen test and a "Name Game". In this game, the probe's location indicates a structure and an explanation of its function is displayed. The learner is expected to name the structure and if the answer is correct, he/she receives one point.

Technical Data: Apple Series. Disk, back-up, manual and student worksheets.

(b) Rationale for Selection

This simulation is certainly the best replacement for the drawings and cuttings listed as learning aids in the HB-Curriculum Guide (p.48). It also helps avoid the use of animals for blood circulation studies (HB-Curriculum

Guide p.49). This means fewer worries in handling microscopes and in dealing with unfavourable reactions of student groups toward animal use.

(ii) HEART ANATOMY AND PHYSIOLOGY

(a) Description of Simulations/Games

This software from the American Heart Association and authored by Alexander and Goodman (1987) contains four programs: Heartbeat, Heartwork, Heartflow and Circulation.

(1) In Heartbeat external motions of the heart are observed.

(2) Heartwork depicts the internal changes in the heart muscles during systole and diastole.

(3) Heartflow demonstrates how blood flows through the heart. It also depicts pressure changes that occur in the Atria and ventricles (i.e. heart chambers) and the actions of the valves. Even the "Lub-Dub" sound that accompanies the valve action is imitated. Technical Data: Apple Series. Disk and manual.

(b) Rationale for Selection

This software is selected simply because it allows the learner to observe the workings of the heart and sounds in a secondary level biology course that would not be very feasible with any other method. Hence, this simulation brings "life" to the laboratory without the

use of live animals, which are often used as replacements for the human organism in such experiments.

(iii) HUMAN CIRCULATORY SYSTEM

(a) Description of Simulations/Games

This is a three part graphic computer simulation by EME (1988). The first component focuses on the heart chambers and systemic versus pulmonary circulation. In the second, blood flow in the heart and body is shown, while the third depicts semi complete circulation through both sides of the heart simultaneously.

Technical Data: IBM/PC, PC/XT, PC/AT or IBM Compatible system with DOS 2.1, 128K RAM, and color monitor. Disk back-up and guide.

(b) Rationale for Selection

No picture or drawing can match the simultaneous effect of blood circulation on both sides of the heart as presented in this program, not to mention showing the flow of blood. Keeping in mind that animal use is now being gradually reduced, this simulation is not just a good replacement for lab animals, but also is effective in creating interest in learning about the circulatory system.

(iv) HEART MEDLEY

(a) Description of Simulations/Games

This is another computer simulation by the American Heart Association, produced by Ruppel et al.(1987), which forms part of the Heart Health Education Series. It is comprised of five animated programs and one game.

(1) Heartwork animates chambers and valves of the heart to show the blood flow through it. A two part quiz follows. The first part consists of sixteen fill-in-the-blanks for which answers must by spelled correctly. The second part has fourteen multiple-choice questions on different parts of the heart.

(2) Heart Attack Risk shows that heredity and lifestyle influence one's chances of heart attack. Students answer some questions about themselves and a bar-graph depicts their own chances of having a heart attack. By manipulating answers, students learn how modifying risk factors can reduce the odds. This conveys the very positive message that the learner has control over his/her own health. All that is needed now is a preventative measure.

(3) Tic-Tac Heart is based on the traditional Tic-Tac-Toe game. Players answer questions about heart health and receive an "X" or an "O".

(4) Heart Jeopardy teaches students about heart disease in a manner similar to the TV game show.

(5) The Healthy Heart Food Game consists of a competition between the player and the computer to see who can win by choosing foods that are lower in cholesterol and saturated fat.

Technical Data: Apple Series. Disk and Manual.

(b) Rationale for Selection

Heart Medley is certainly effective in teaching students about heart health. Equally important is the message that eating habits are under one's own control, as are the ways to reduce risk to heart health. Competition with the computer is expected to make learning more enjoyable and concept attainment easier.

(v) ALIEN

(a) Description of Simulations/Games

Created by Kosinski (1989), this simulation depicts cardiopulmonary physiology of humans and extraterestrials. The player selects experiments to answer sixteen questions. Experiments include: (i) effects of altitude on running strength, (ii) homeostasis of blood gases (i.e. equilibrium of oxygen and carbon dioxide), and (iii) distance run, as a function of running speed.

Technical Data: Apple IIe or IBM/PC. Disk, instructor's manual and student exercises.

(b) Rationale for Selection

This software is interesting in that it involves children in the study of cardiopulmonary physiology of extraterrestrials. As we know, children of all ages get very excited over anything that has to do with E.T.'s and UFO's. This fact alone will make learning fun for students. Since very limited information was available on this software, its other aspects are difficult to assess at this point. Overall headings of programs mentioned however, seem to be useful for learning the concepts outlined by the inventor of this simulation.

(vi) EVERYBODY WINS: AN ORAL ASSIGNMENT LOTTERY

(a) Description of Simulations/Games

This is an oral exercise game designed by a biology professor, Louise Squitieri (1986), at Bronx Community College. The cardiovascular lottery begins by winning a "blood vessel". The students' names are put in one "hat" and those of the blood vessels in another. Students draw from both hats simultaneously. Every student wins a blood vessel fairly and publicly in the classroom setting and then is to make an oral presentation on his/her win. Students must organize their presentation in the following manner:

(1) Introduction of blood vessel

This includes stating the names of the blood vessels and describing their location and the part of the

body to which they supply the blood (arteries) or drain (veins) blood from.

(2) Main body of the assignment

In this case the student traces the blood flow to and from the body parts by a specific blood vessel. In their descriptions students must: (i) use the appropriate terminology, (ii) name the blood vessels in the order the blood flows through them, (iii) name the heart chambers and valves in the order the blood passes through them, (iv) mention approximate ratios of oxygen and carbon dioxide in all the blood vessels and heart chambers and (v) outline the presentation on cue cards.

Evaluation of the students' performance is based on the content, description and use of anatomical terminology and organization on the cue cards and how well they presented it.

(b) Rationale for Selection

Four of the many advantages are listed below as the author herself saw them:

(1) This lottery format can be applied to the study of any other anatomical concept in human

biology; for example, the skeletal system.

(2) Repeating exercises helps the student learn how to organize information and search for accuracies.

(3) Class presentation using cue cards should improve students' oral communication skills.

(4) Students naturally learn about the concepts by completing the assignments.

An added advantage of this game is that it can be played in any school setting, as long as the students have access to relevant books. The game does not require any special facilities.

(vii) BLOOD TYPE TEST

(a) Description of Simulations/Games

This simulation is a joint effort of a biology-chemistry team of instructors at John Tylor Community College (Sharp and Smailes, 1989). It is non-computer simulation that tests the blood types without using real blood. It relies on certain chemicals which are used to simulate blood. It exploits the property of certain ionic solutions to form or not to form a precipitate when mixed together. The solutions that form a precipitate are treated as a positive test whereas no visible change in solutions containing ions is a sign of negative results.

of negative results. In this manner, the team has developed simulated Antisera A and B, as well as simulated blood types: A, B, AB and O. Precipitation is taken as a sign of agglutinogen presence corresponding to the agglutinogens of the four blood types.

The testing procedure utilizes transparent plastic petri dishes or concave depression slides. With petri dishes, three to four milliliters of simulated blood is used. The depression slides require an economical use of solutions since only two to three drops of simulated blood are needed. To these blood samples, the addition of one to three drops of simulated antisera is enough to bring about the reaction. A precipitate would mean the presence of antigen, whereas the reverse is true for its absense. The important thing is that students should be told that antigens are found on the red blood cells and antisera occur in the blood serum. Blood serum is plasma minus clotting factors, i.e. blood platelets.

(b) Rationale for Selection

One cannot help but agree with Sharp and Smailes that:

(1) It helps students visualize antigen-antibody reactions.

(2) It can be used to test samples of an undetermined nature since the identity of

Antisera A and B is always known (in simulated samples of course).

(3) Simulated blood is a safe approach to blood-tests since the risk of AIDS and the Hepatitis virus is eliminated.

(4) It can be used under the normal laboratory safety procedures necessary for handling chemicals.

Solutions used by the authors to prepare antisera and blood types are listed in Table 1.

(viii) BLOOD PRESSURE RUMMY

(a) Description of Simulations/Games

A non-computer game devised by a biologist (Walsh, 1986) at Piedmont Virginia Community College, uses fifty cards which lend it the name "rummy". Each term card bears an anatomical or physiological term from any system of the human body. These selected terms in some way or other relate to blood pressure control.

The teacher initiates the game by drawing seven term cards and writing them on the board. The next step involves declaring either hypotension (low blood pressure) or hypertension (high blood pressure). Students then rearrange the cards in logical order, corresponding to the prescribed situation. If one begins

with low blood pressure, then the cards must be arranged in such a manner that they reveal the reactions or steps the body would take to raise blood pressure back to normal. Students work in small groups under the following rules: (i) each student must try to find the logical sequence to correct the imbalance and describe the role of each term, (ii) students may guide each other by giving clues but not by providing correct answers.

(b) Rationale for Selection

The advantages of this exercise are that it is of high educational quality as described by the author:

(1) Random card selection provides numerous interactions.

(2) A set of the same seven cards could yield different sets of acceptable explanations, thus reinforcing the notion that there is no single correct answer.

(3) This exercise fosters critical thinking which requires good command of the subject matter.

When compared with the recommended strategies of the Human Biology Curriculum Guide (p.52), it becomes evident that it offers a far superior method of learning since it is the only game encountered that facilitates critical thinking. Used in conjunction with activities such as feeling one's pulse, listening to the heartbeat and taking blood pressure (HB-Curriculum Guide, p.54) it supplements the learning about blood pressure.

2. DIGESTION

The three sections from the fourth and fifth units of the nutrition module are grouped here under the heading of digestion. The fact is that cell activities, utilization of carbohydrates and fats, and balance between food-intake and activities are directly related to the substances obtained from the process of digestion.

i. Cell Activities

A. Objectives and Teaching Strategies

Cellular activities involve cellular respiration. The main objective of this section (HB-Curriculum Guide, p.22) is to familiarize students with this phenomenon since cellular respiration is the energy producing process of a living system. Energy and carbon dioxide are two major by-products of cellular respiration. Intermediate (HB-Curriculum Guide, p.22) or specific objectives also include the knowledge of (i) the role of oxygen, (ii) comparison of energy supplied by fats, carbohydrates and proteins, (iii) principal waste products and (iv) importance of elimination of wastes. Kreb's cycle and deamination of amino acids, though not listed under intermediate objectives, are recommended in a cursory fashion (HB-Curriculum Guide, p.61) as an enrichment activity.

Teaching-learning activities include the use of a diagram for explaining the relationship that exists between digestion, repiration, circulation and cellular activities.

To facilitate the understanding of complex processes at the cellular level use of analogies, such as wood combustion, is also suggested (HB-Curriculum Guide, p.62).

B. Simulations and Games

For "Cell Activities" only one software, namely, "Metabolic Marathon" was found and included here.

METABOLIC MARATHON: A Computer Game

(a) Description of Simulations/Games

This game was created by Scott Zimmerman of BrighaYoung University (1986). It offers eight metablic pathways. Students "run a race" by answering questions and choosing the path, length and time of the race. Correct answers move him/her ahead quickly while racing within the constraints of length and time. Therefore, wrong and slowly-entered answers leave the contestant behind in the race.

Technical Data: Apple II+, IIe or IIc and compatible microcomputers with DOS 3.3 and 48K memory. Disk, archival copies and user's manual.(b)

(b) Rationale for Selection

This commercially prepared game exploits the children's interest in computer games for course concept learning. Learning Kreb's cycle and deamination processes is a difficult task which is thus made easy and interesting. Winning the race should also keep students

interested. An ddition al benefit could be derived by using the game as a practice drill.

ii. Utilization of Carbohydrates and Fats

A. Objectives and Teaching Strategies

Food assimilation through cellular activities provides fuel for various bodily functions. The terminal objective therefore is to make students understand the relationship between food-intake energy and its expenditure (HB-curriculum Guide, p.23). Keeping pace with this aim, the intermediate objectives revolve around the functions and calulations of food intake energy (HB-Curriculum Guide, p.24).

The recommended approach to teaching-learning is a simple one. Learning includes measuring the body temperature, calculating values of food consumed, and energy expenditure for different activities. A guided class discussion is also suggested following these activities (HB-Curriculum Guide, p.68).

B. Simulations and Games

Only one simulation was obtained on the topic related to the utilization of food-intake:

HUMAN ENERGY EXPENDITURE: A Computer Simulation.

(a) Description of Simulations/Games

This is a Longman Micro Software simulation (1979) which allows students to explore energy expenditure in relation to activity, gender and body weight without any

calculations. Students could also compare these factors with the food they eat.

Technical Data: Apple IIe. Disk, back-up and manual.

(b) Rationale for Selection

It is known that very few students enjoy the tedious work that is involved in manual calculations. Work like this distracts and impedes cognitive learning. This simulation is helpful in avoiding calculation and saving time that can be spent grasping the concept. Students' interest is maintained because they can learn the differences of energy expenditure and energy values of their food with a touch of a finger.

iii. Balance between Food-Intake and Activities

A. Objectives and Teaching Strategies

This section comes under unit five entitled "Utilization of Intake" (HB-Curriculum Guide, p.24). Implicit in the learning of this concept is the importance of a balanced life style (HB-Curriculum Guide, p.24). Specific objectives are aimed to enable the students to learn to:

(1) Evaluate their diet and activities

(2) Locate resources for a balanced diet and activities

(3) Know the benefits of a balanced lifestyle

Learning activities suggested for evaluation purposes include the preparation of an activity list to check dietary

intake. A survey approach is also recommended for locating resources (HB-Curriculum Guide, p.69).

B. Simulations and Games

The relationship between activities and food intake was depicted in only one computer game:

LET'S GET PHYSICAL: A Computer Game.

(a) Description of Simulations/Games

This is a computer game from Orange Cherry Software(1989) which helps students design a physical fitness program and a diet plan. By asking the user's age, gender and favourite exercise, the computer displays a list of exercises to fit these parameters. The concept of "3-target-20" is explained. It means exercising three days a week for twenty minutes with the heart rate kept at the target level. The next step involves students taking and entering their pulse in the computer. It flashes back a chart with target zones for various age groups. students choose the target suitable for them. Calories are defined to assist in designing a suitable diet plan. browsing through the calorie-count of different leaner foods they design a personal diet plan.

Technical Data: Apple Series, Commodore 64/128, TRS-80. Disk, back-up and manual.

(b) Rationale for Selection

The game is useful for both human biology and physical education classes. Time spent on activities

like surveys can be saved because this program presents an inventory of exercises to choose from. The great similarities of the learning activities suggested (HB-Curriculum Guide, p.69) and options offered in this program make it a worthwhile supplementary aid to the teaching of human biology.

3. LOCOMOTOR SYSTEM

The locomotor system forms the second unit of the module called "Relationships". It is based on two sections: skeleton and muscles, both of which are responsible for body movement.

i. Skeleton

A. Objectives and Teaching Strategies

"Skeleton", the first section of the locomotor system, aims to describe the two major formations of skeletal system: (i) provide support to the vescera, that is, soft organs and (ii) movement to body parts (HB-Curriculum Guide, p.33). The understanding of the skeletal function requires the knowledge of its structure, development and growth, as well as the composition of its bones. However, greater emphasis is placed on the interrelation of bones and the movement of the body. Therefore, learning content also stresses the function of joints, ligaments and cartilage. These components give the skeletal system its flexibility.

Learning activity is also based on making the models of joints and/or groups of bones with cardboard, wood and elastic bands (HB-Curriculum Guide, p.112). For other intermediate objectives such as bone structures and their compostion, simple observations of bones, bone fracture and demineralization of bone pieces in acid are suggested (HB-Curriculum Guide, p.112).

B. Simulations and Games

SKELETAL SYSTEM: A Computer Simulation

This simulation is developed by Garret (1983 a). It provides the opportunity of studying every aspect of the skeletal system, hence the inclusion of one software on this topic was considered sufficient.

(a) Description of Simulations/Games

This computer simulation from Brain Bank (1983) is very much in line with the objectives of skeleton content of the Human Biology Curriculum Guide (HB-Curriculum Guide, p.33).

Technical Data: Apple IIe. Disk, back-up and manual.

(b) Rationale for Selection

It teaches the names of some major bones in the human body. It also depicts the functioning of cartilage and ligaments. Workings of the joints are also displayed along with the compostion of the skeletal bones. The functioning of the joints and ligaments is the most interesting feature of this simulation because

visualization makes it easy to understand. The greatest benefit is to study this functioning process without going through the trouble of making models. The graphic nature of the simulation allows students to make the joints move. It would certainly supplement the study of the functions of the joints and ligaments.

4. NERVOUS SYSTEM

A. Objectives and Teaching Strategies

The nervous system forms a section of "Sensory Relationships" which in turn is the first unit of the relationship module. The main theme here is that students should be able to understand and explain the functioning of the central nervous system. Intermediate objectives, though only six in number (HB-Curriculum Guide, p.32), deal with the complex learning material as follows: (i) parts of the central nervous system, (ii) impulse transmitting structures, (iii) function of brain, (iv) central nervous system and intellect and its improvement and, (v) consequences of nerve damage through injury or drug abuse.

Suggested learning activities to understand the complex content of the nervous system include making drawings and use of diagrams (HB-Curriculum Guide, p.104). It is expected that by making drawings, students would be able to grasp the complexity of stimulus transmission.

B. Simulations and Games

The Epilepsy Foundation of America provided the best software for the study of morphology and physiology of the central nervous system:

EXPLORING YOUR BRAIN: A Computer Simulation.

(a) Description of Simulations/Games

This simulation is a contribution of the Epilepsy Foundation of America (1983) and is an interactive computer program which encompasses all the aspects of the nervous system section listed in the intermediate objectives (HB- Curriculum Guide, p.32). In fact, it presents the following content in detail:

(1) Geography of the brain with all of its major parts and their function

(2) Circuits of brain--sensory motor and neuronal transmission

(3) Misfiring of brain circuits--loss of control over impulse transmission and its prevention

(4) Brain malfunction and social response--basically epileptic seizure and its personal and social implications.

Technical Data: Apple IIe. Disk and manual.

(b) Rationale for Selection

Although, it puts special emphasis on a detailed terminology which the Quebec Human Biology Curriculum

deemphasizes, the program is very suitable for the understanding of brain structure and functions, especially its malfuncitons. It is also believed that computer interaction is a better approach to learning than through making drawings as suggested in the Human Biology Curriculum Guide (p.104).

5. REPRODUCTIVE SYSTEM

Reproduction is the third module in the Quebec Human Biology Curriculum. This model provides the study of male and female reproduction systems and their physiology. The fundamental aim is to make students aware of the processes involved in procreation so that they make responsible choices. The two units of this module contain fourteen sections. In the context of the present study, however, only the following are of interest:

i. Menstrual cycle
ii. Pregnancy: normal consequences of fertilization
iii. Pathological consequences of sexual intercourse

i. Menstrual Cycle

A. Objectives and Teaching Strategies

"Menstrual Cycle" is a section of the unit on anatomy and the physiology of reproduction. It proposes to teach that the menstrual cycle is a physiological phenomenon of distinct phases influenced by hormones (HB Curriculum, p. 37).

specific attention is given to the following aspects:

(i) Changes that accompany menstrual cycle

(ii) Action of ovarian hormones

(iii) Time of ovulation

(iv) Signs used to identify ovulation time

(v) Significance of ovulation and features of ovum

B. Simulations and Games

CYCLE: A Computer Simulation

(a) Description of Simulations/Games

This simulation developed by Kosinski (1989) contains three programs: (i) the menstrual cycle, (ii) human fertility and (iii) preganancy. Games of various difficulty are included. Relatively easier ones are on hormonal data, basal body temperatures and follicle diameter. For the difficult one, only menstrual flow is depicted.

Technical Data: Apple IIe or IMP/PC. Disk, instructor's manual and student exercises.

(b) Rationale for Selection

The menstrual cycle game allows students to predict fertile periods of a simulated woman with variable-lengths of cycle. The prediction of infertility too close to ovulation time bears a heavy penalty since pregancy is

already underway. Correct prediction gains points. By changing the secretion rate of hormones, the user can study the effects of hormonal variations on the cycle. This software accommodates the variations for estrogen, progesteron, luteinizing hormone (LH) and follicle stimulating hormone (FSH). It also permits experiments on the effect of oral contraceptives.

ii. Pregnancy: The Normal Consequence of Fertilization

A. Objectives and Teaching Strategies

The third section of the unit on the physiology of procreation covers pregnancy. The knowledge required concerns the relationship between a developing embryo and the progress of the pregnancy. Seven specific objectives are mentioned in the curriculum document (p.42). One of particular interest to this paper relates to the basis of the pregnancy test.

Teachers are advised to have students prepare questions on pregnancy and invite a pregnant woman to answer their quesitons or give a lecture (HB-Curriculum Guide, p.148).

B. Simulations and Games

Two simulations have been chosen for teaching the pregnancy-related topics. One of these utilizes the principle of the pregnancy test and the other deals with the effect of alcohol on the fetus.

(i) ARTIFICIAL URINE TEST: A Non-computer Simulation

(a) Description of Simulations/Games

The principle of the pregnancy test is used to develop artificial urine and its basis is that the urine of pregnant women contains a hormone called Human Chorionic Gonadotrophin (HCG). This hormone is secreted by the trophoblast stage when the embryo is only eight days old. The HCG is excreted in the urine of pregnant women from about the eighth day of pregnancy and reaches its peak at approximately the eighth week of pregnancy.

This simulation was developed by a biologist named Russo (1987) who uses an "artificial urine" which is a solution of HCG used on a glass slide. To this, an Anti-HCG antibody is added. Then HCG-coated latex particles are also mixed. The antibodies are first allowed to react with antigens in urine samples before they are mixed with coated-particles for clumping. Therefore, in pregnancy tests, positive results signify an inhibition of precipitate or clumping. This lack of agglutination accounts for the positive results for pregnancy.

Positive reaction for pregnancy	=	Reacted Antibody	+ Antigen coated particles	= No Agglutination

(Refer to Table 2 for materials, procedure and suggestions)

(b) Rationale for Selection

This simulation is unique in that it uses "artificial" urine in place of "real" urine. Obviously there are explicit advantages for the teaching-learning of the pregnancy test at the high school level and these are listed as follows:

(1) Materials needed to prepare "artificial" urine are available commercially

(2) Problems associated with handling and storing of "real" urine are avoided

(3) Risk of non-hygenic encounters with "real" urine is reduced

(ii) ALCOHOL AND PREGNANCY: A Computer Simulation/Game

(a) Description of Simulations/Games

This is a simulation/game combination prepared by Student Awareness Software (1989). It has nine programs concerning the interaction between alcohol and the unborn child and begins with a game-format simulation which depicts what a child would look like if one could design it. Programs cover many subjects, including: (i) history and traits of fetal alcohol syndrome, (ii) fetal alcohol effects, (iii) interaction between nutrition, alcohol, the human body and fetus, and (iv) a series of simulation questions. The program contains lots of reading material.

Technical Data: Apple Series. Two double-sided disks. Teacher's resource management disk and manual.

(b) Rationale for Selection

This simulation is extremely useful in enhancing one's knowledge about health- and nutrition-related aspects of pregnancy. It would be equally useful in health education and counselling. The simulated design of the developing fetus, as affected by its mother's alcohol consumption, provides a realistic depiction which is easily comprehensible.

iii. Pathological Consequences of Sexual Intercourse

A. Objectives and Teaching Strategies

This forms the section of the unit on the physiology of procreation, specifying the knowledge and behavior related to sexually transmitted diseases (HB Curriculum, pp.43-44) This course is especially interested in raising awareness about the most widely spread sexually transmitted diseases such as AIDS, gonorrhea, herpes and syphilis. The symptoms and methods of prevention are given a high priority in STD awareness education. In the case of contracted STD's, early consultation with a doctor and informing the partner are also emphasized (HB Curriculum, p.151).

Teaching strategies stress the importance of informing students in various ways. One such way is the use of guest speakers from nursing or community health services. An additional benefit of inviting these experts is that they also provide information packages for students (HB Curriculum, p.152).

B. Simulations and Games

Pathological consequences of sexual activities are manifested in the form of many contagious diseases. Our search for simulations and games has revealed one simulation for syphilis testing and one which explains the transmission of contagious diseases.

(i) AGGLUTININ TEST FOR SYPHILIS: A Non-Computer Simulation

(a) Description of Simulations/Games

This non-computer simulation by Miller (1987) explores the principle of agglutinin reactions which are in common use for the testing of ABO blood types. The same principle is applied in the serologic tests for syphilis and pregnancy.

REAGIN TEST FOR SYPHILIS

The Treponema pallidium bacterium, the causative agent of syphilis, is difficult to obtain in pure cultures, so its use as an antigen is practically impossible. Therefore, serologic tests for syphilis use a chemical called cardiolipin, a glycoside which

is found in normal cardiac tissues. Early syphilis infection through degenerative action causes the release of cardiolipin. The body's immune system counteracts the cardiolipin by producing an antibody called reagin. Tests for syphilis are aimed at detecting this antibody. Test-kits for syphilis are commercially available. Most kits contain cardiolipin-coated particles, negative and positive sera. Some kits do not provide these sera; however, they can be bought separately. The test is performed simply by putting a drop of serum (containing the antibody) on a glass slide and adding the antigen (i.e. cardiolipin). The two chemicals are then mixed well, using a toothpick to stir them. A positive test for syphilis begins to show agglutination within five minutes. No agglutination means that the test is negative for reagin, hence also for syphilis.

Reagin positive reaction for Syphilis	=	Antigen (Cardio-lipin coated particles)	+ Antibody (Serum w/ Reagin)	= Agglutination (Clumping)

(ii) SIMULATION OF DISEASE TRANSMISSION

(a) Description of Simulations/Games

Disease transmission is an interesting topic and can apply to both sexually transmitted diseases as

well as to other contagious diseases.

Studying disease transmission in a classroom setting is not an easy task. However, an ingenious yet simple technique has been developed by Dickey (1989), a biologist at Clemson University, South Carolina. It requires commonly used chemicals from the chemistry lab. Dickey has worked out a way to demonstrate to students the transmission of diseases and how to trace them back to the first infected contact.

Each student is supplied with a stock bottle of solution, a clean test tube and a disposable pasteur pipet. All stock bottles contain dilute 0.001N of HCl (i.e. hydrochloric acid) except one which contains 0.1N of NaOH (i.e. sodium hydroxide). Students are unaware of this difference since it is not visible to them. The assumption is that an infected individual has no symptoms. These solutions can represent anything one wishes, for instance, "bodily fluids" responsible for AIDS spread. Students are reminded of safety procedures for handling chemicals before the transmission round begins.

In the first round, each student transfers three pipettsfull of his solution to a clean test tube. Then he/she randomly finds one person and exchanges a

dropperful of solution. This way both parties have made an exchange of solution. Only one such contact is allowed in the first round and students record the name of his/her contact.

The teacher signals the second round and each student finds a different contact. They exchange solutions in the same manner as in the first round, recording each other's names again.

The third round is a repetition of the procedure in round two.

After the third round, all students add one dropperful of phenol red to their test tubes to see if the solution contracted the "disease". They then record their solution's color change. "Infected" solutions are red and "non-infected" ones are yellow. The teacher also keeps a record of the contacts of "infected" individuals. Students can then trace the original source of infection (Fig. 1 & 2 in Appendix A).

(b) Rationale for Selection

It is believed that this simulation provides a most exciting, easy and useful exercise in promoting understanding of disease transmission. It would supplement the existing activities as well as enhance comprehension of this phenomenon. It could also be

applied to any disease whose spread is similar to that of AIDS.

6. SENSE ORGANS

"Sense Organs" forms a part of Unit One, entitled "Sensory Relationships" which belongs to the module "Function of Relationships". This unit deals with the eye and ear structures and physiology. Two simulations and games have been selected and presented here:

i. Special Senses (vol I): EYE

A. Objectives and Teaching Strategies

The curriculum objectives emphasize the anatomical structure and physiology of the eye. The EYE curriculum's intermediate objectives (HB-Curriculum Guide, pp.27-28) require that students: (i) draw the cross section of the eye, (ii) differentiate between transparent areas and the eye membrane and, (iii) list the role of each eye membrane and all the transparent areas.

Physiological studies include: (i) study of the optic nerve structure, (ii) transmission of nerve impulse in the optic nerve, (iii) path followed by light rays inside the eye, and (iv) optic areas and center of vision.

The teaching strategies involve simply drawing, pasting and coloring to identify and label eye parts (HB-Curriculm Guide, p.86). Activities such as looking into each other's eyes or their own in the mirror are also suggested (HB-Curriculum Guide, p.86). The comparision of the role of

the retina with that of the photo-electric cell is also considered useful in understanding the changes in light waves (HB-Curriculum Guide, p.86).

B. Description of Simulations/Games

This simulation created by Perelberg & MacDonald (1986 a),teaches eye anatomy optics and the mechanism of human vision in logical sequence.

Technical Data: Apple II+, IIe or IIc and compatible microcomputer with DOS 3.3 and 48K memory. Price includes archival copies and manual.

C. Rationale for Selection

The mechanism of optics alone makes this a worthwhile selection for eye study.

ii. Special Senses (Vol. II): EAR

A. Objectives and Teaching Strategies

The Human Biology Curriculum requires that students learn the antomy and physiology of the human ear. Three objectives are listed which include: (i) study of external, middle and inner ear parts, (ii) structures involved in sound transmission, and (iii) locating the recepter, transmitter and interpreter involved in hearing (HB-Curriculum Guide, p.29).

Teaching-learning involves the same method as that suggested for the study of the eye. However, for the transmission of sound, the simple experiment of placing sand on a tambourine was suggested to see how easily it vibrates.

A stethoscope is also recommended (HB-Curriculum Guide, p.94) to hear the heart beat and to learn how sound is transmitted through solids.

B. Descriptions of Simulations/Games

This computer simulation created by Perelberg & MacDonald (1986 b) uses a combination of graphics, animation and interaction to present the anatomy of the ear and the mechanics of hearing.

Technical Data: Apple II+, IIe, IIc and compatible microcomputer with DOS 3.3 and 48K memory. Price includes archival copies and manual.

C. Rationale for Selection

The animated mechanism of sound transmission and graphics to explain the ear anatomy are attractive features in using this simulation as a teaching aid. Most valuable is the animated transmission aspect for really understanding sound transmission. Normal lecture methods rely on mere descriptive accounts.

7.HUMAN BODY

Four softwares are included under this heading:Anatomy Challenge,Human Body:An Overview,That's Life:Human Body Exploration, and Adventure in Flesh. Since there is an overlap of concepts covered in these softwares with those described earlier, their detailed description is omitted here.

Technical Data: Apple II Series (for all these 4-softwares).

2. Summary of Chapter II

Chapter two forms the bulk of this monograph. It includes a detailed analysis of the simulations and games selected for Quebec's Ecology (Secondary I) and Human Biology (Secondary III) programs. This chapter was divided into two sections:

1. Section A: Ecology
2. Section B: Biology

The section on Ecology was based on the description of twenty-one simulations and games selected for the teaching - learning various ecological topics. They are arranged under seven headings and listed in Appendix B.

The section on Human Biology contains the description of twenty simulations and games out of the twenty-four selected and listed in Appendix C. The last four simulations and games not treated in the text contain topics that overlap with those described in detail under the first twenty.

A similar pattern was used for the treatment of all the simulations and games related to Ecology and Human Biology:

(i) Curriculum objectives and teaching strategies

(ii) Description of simulations/games with mention of technical data.

(iii) Rationale for simulations/games selection.

CHAPTER III

GENERAL CONCLUSION

AND SUMMARY

CHAPTER III

General Conclusion and Summary

1. Introduction

It is an historical fact that the needs of the time dictate the content and instructional strategies of the educational enterprise. In the past, the aim of liberal education was to produce discipline scholars. Therefore, didactic approaches to teaching-learning proved beneficial. In the post-Sputnik era, the space race between the super powers demanded that schools turn into processing plants to train young minds in both the principles and the processes of science. It was then that the laboratory became an integral part of science teaching to employ the scientific method of learning. However, learning by discovery was in reality limited to imitating the scientist rather than acting like one. Students learned the scientific procedures of "discovery" by repeating experiments of known outcome. Although, these methods still form part of science teaching, they are not considered adequate in preparing today's youth for the task of resolving the science- and technology-related problems of the future generation.

One of the major goals of current science education is to prepare a scientifically literate citizenship. This has resulted in the search for teaching strategies which provide experience and practice in problem solving, and which also

stimulate critical thinking. Simulation and gaming is considered an opportune method for fulfilling such a need.

Simulation and gaming techniques are favoured by the new trend which advocates the introduction of fresh approaches to teaching. Lunetta and Hofstein (1981) suggest that in the future "hands-on" experience as well as simulations and games should be incorporated in the laboratory within the realm of science education. A similar belief is echoed by Toval and Flores (1987) who predict that simulations will play an important role in the changing face of education.

2. Educational Implications

(a) Psychological Foundations

Simulations and games have their basis in the psychological and physiological concept of play. World renowned psychologists have extablished a close relationship between playing and the cognitive development of children. Freud arrived at this conclusion by observing children expressing certain ideas through play which they would not otherwise express (Bettelheim, 1972). Similarly, Piaget noticed the social and intellectual development of children playing marbles (Piaget, 1976). Both Freud and Piaget believe that play is the essence of psychological development. Piaget's theory of play (Developmental Theory) considers playing fundamental to the growth of intelligence. Accordingly, the child's

intellect grows by means of a series of processes in which he/she makes mental adjustments to new sets of information. The processes of assimilation, accommodation and equilibrium are three important phases of Piaget's Developmental Theory. The assimilation process involves taking in information and incorporating it into the existing storage of knowledge. Accommodation requires that the human organism make some adjustment in order for assimilation to occur. Only when an equilibrium is reached between the two processes, can cognitive growth occur.

Based on the work of Piaget, science education has developed a three-phase learning cycle (Karplus, 1977). The importance of this learning model has also been affirmed in the teaching of science (Abraham & Renner, 1986 and Renner et al., 1986). In science teaching-learning, this cycle translates into: (i) initial exploration, (ii) concept formation, and (iii) concept application. It is believed that for optimum comprehension to occur all three phases are required.

Play or its modified forms, i.e. simulations and games, create conditions conducive to assimilation and hence learning. Therefore, simulations and games benefit the intellectual development of learners. Many studies reveal that simulations and games enhance learning, as is evident in many empirical findings.

(b) Empirical Evidence

Simulations and games are known to foster motivation towards learning. They have also shown a positive correlation with many other desirable goals that education aims to achieve. Some of these include motivation, cognitive retention, transfer of knowledge, problem-solving, decision making, and affective learning. These traits appear to correspond to the aims of both American and Canadian reform initiatives. It is believed that Ecology and Human Biology students would benefit immensely by using the simulations and games included in this study. An analysis of the traits listed above will further prove the need to include the simulation-gaming method as a teaching aid.

Motivation:

Academic simulations and games are acclaimed for high motivational value. In literature many reasons are mentioned which explain this particular trait. It has been suggested that simulations and games increase motivation because they provide fun and enjoyment (Orback, 1979), challenge and fantasy (Loftus and Nelson, 1984), excellent opportunity to participate actively in the learning process (Bruner, 1967) and the chance to be involved in decision-making (Maxson, 1973).

Cognitive Retention:

Active participation in simulations and games helps one remember facts learned because they are used in an enjoyable manner in simulation exercises (Maxson, 1973 and Orbach, 1979). Bredemeier and Greenblat (1981), and Heitzmann (1974) cite many studies which conclude that simulations and games facilitate cognitive retention.

Transfer of Knowledge:

The importance of the transfer of learning-outcomes to real life situations is also emphasized in the reform initiatives. If learners are to become scientifically literate for the purpose of participation in decision-making, then the ability to transfer knowledge and skills learned in school is vital. Through simulations, students learn to deal with situations which are miniatures of real life. Studies show that by providing a choice of approaches to problem-solving, simulations and games help increase the transfer of knowledge (Maxson, 1973 and Ryan, 1968).

Problem Solving and Decision Making:

Simulated situations also provide the advantage of freedom from the consequences of wrong actions or decisions. It makes the learner feel free to try as many options as needed in solving problems or making decisions (Sylva et al., 1976). Being free from fears and threats, he/she can learn the art of problem-solving and decision-making in a relaxed manner. Finch

and O'Reilly (1974) consider simulations the best tool for providing the opportunity for trouble-shooting instruction.

Affective Learning:

Another feature for which simulations and games are known is their effectiveness in bringing about attitudinal changes in learners. The simulation-gaming approach is especially found to be effective in the development of awareness and appreciation towards science education (Reid, 1979).

In addition to the five areas of simulation-gaming effectiveness mentioned earlier, there are a few more which merit mention. These are related to the integrated approach towards knowledge. Simulations and games require the employment of all the senses by virtue of demanding that the user be an observer and participant at the same time. Hence, they provide a multisensory experience and holistic insight to learning.

It is evident from the aformentioned traits of the simulation-gaming strategy that its use will prove beneficial for the effective teaching-learning of Ecology and Human Biology concepts. It is also believed that there exist a sufficient number of simulations and games suitable for teaching the concepts not covered in the present study. The trend towards simulation and game use is on the increase due to the fact that, in addition to the commercially-developed simulations and games, there are many available that have been

developed by science educators. However, there still is some hesitance on the part of many science teachers to employ the simulation-gaming method.

Difficulties in the Introduction of Simulation/Gaming Method:

In spite of so many desirable features, the simulation-gaming approach faces some obstacles in its implementation in the school system as a viable alternative. Saegesser (1981) lists them as (1) temporal, (2) spatial, (3) organizational, and (4) related to methods of evaluating learning. These are the major problems facing simulation and game use on a wider scale in the school setting.

(1) Temporal Constraints

Traditional temporal organization of schools is based on the fixed 45-minute class period. On the one hand, the use of simulations and/or games requires more time than forty-five minutes and this precludes the possibility of benefiting from the simulation-gaming approach. On the other hand, it demands a major adjustment to fit them into a rigid schedule. Open modes, like that of simulation-gaming, allow for more creativity and are, therefore, more difficult to adjust to in such constraints of time.

(2) Spatial Arrangements

The existing arrangement of classrooms are also unfavourable for non-computer role playing simulations and games. Whereas with computer simulations and games,

there is the problem of limited space for the accommodation of hardware, even if it is economically feasible for a given school.

(3) Evaluation Strategies

Conventional evaluation methods are intended to measure the desired outcome of learning and are equated with the acquisition of knowledge. These techniques are not suitabl for measuring the knowledge acquired from personal experiences with simulations and games which involve internalized knowledge. This interferes with a proper evaluation of learning comprehension. To popularize the use of the simulation-gaming approach in science teaching, therefore, means the revamping of some of the existing practices and structure of schools.

3. Recommendations

In this "Age of Information", the use of microcomputers is increasing rapidly. The educational system must, willingly or unwillingly, undergo change in order to keep pace with today's new technology. It appears that the educational system requires change at all levels: administration, curricula and methods of instruction. The simulation and gaming approach appears to be the method of teaching for the future, most notably the computer simulations.

Some fifteen years ago, Greenblat (1975) suggested that the learning environment should provide for (p.7):

(i) Perspective learning: Learner should have the chance to explore many perspectives

(ii) Autotelic learning:	Learner's activities containing their own goals and sources of motivation
(iii) Productive learning:	Learner should be independent of authority to reason
(iv) Reflective learning:	Learner evaluating his/her own progress

Implicit in these suggestions is a hint of an instructional strategy that could provide for such learning. Simulation-gaming appears to fit such a learner-generated, learner-controlled and playful strategy. Therefore, it is expected that teachers in our schools would favour the simulation and gaming approach to teaching. Hopefully, teachers responsible for Quebec Ecology (Secoondary I) and Human Biology (Secondary III) instruction will benefit from the collection of simulations and games presented in this study.

4. Summary

This monograph reveals the efforts underway towards the reform of science education both in Canada and the United States. One emphasis of these reform initiatives is the utilization of new instructional strategies. These initiatives seem to favour simulations and games for science education in the future.

In this monograph an account of simulations and games is presented. These simulations and games pertain to the concepts taught in the Quebec Ecology (Secondary I) and Human

Biology (Secondary III) programs. The collection includes both computer and non-computer simulations and games. Most of the simulations and games reviewed in this study are commercially available. However, some which were created by the science teachers at the classroom level were obtained from articles published in scientific journals. Simulations and games covering ecological concepts include both recently developed ones as well as those developed in the early seventies. There exists a wide range of simulations and games on the topic of pollution. For the purpose of this monograph however only eight were thought to be a sufficient number for representation.

The search for Human Biology related simulations and games revealed that these are the result of recent developments and thus mainly made for computers. There is a large amount of software on topics related to Human Biology, especially on the cardiovascular system. However, teacher-created simulations also exist and are economically more feasible. An encouraging number of simulations and games were selected and reviewed.

A general pattern was followed for reviewing the purposes of all the aforementioned simulations and games. First the Quebec Curriculum objectives and teaching strategies were mentioned concerning the concept for which a simulation and/or game was chosen. Then a descriptive account was given which was followed by the rationale for that particular simulation and/or game's inclusion. For each software, information

pertaining to technical data was also supplied so that the user would know what type of computer hardware is required. To assist teachers interested in obtaining a certain software, a list of simulations and games with the company's name and address is provided in Appendices B and C.

In Chapter Three, the educational implications for the use of the simulation-gaming strategy have been considered. An attempt has been made to establish the effectiveness of simulation and game use in education. The need for changes in teaching-learning practices is also emphasized.

TABLES

TABLE I

SOLUTIONS COMPOSITION FOR SIMULATING
ANTISERA AND BLOOD GROUPS

Table 1. Recommended Solutions for Simulating Antisera A and B and the Four Blood Groups

SUBSTANCE SIMULATED	*DIRECTIONS*
Anti-A	Use 0.20 M solution of NaI (sodium iodide) and place in dropper bottles labeled "Anti-A." 3.00 g/100 ml. distilled water
Anti-B	Use 0.20 M solution of $AgNO_3$ (silver nitrate) and place in dropper bottles labeled "Anti-B." 3.40 g/100 ml. distilled water
Blood type A	Use 0.20 M solution of $Pb(NO_3)_2$ (lead nitrate) and place in bottles that can be capped labeled "Blood type A." 6.62 g/100 ml. distilled water
Blood type B	Use 0.20 M solution of $BaCl_2$ (Barium chloride) and place in bottles that can be capped labeled "Blood type B." 4.16 g/100 ml. distilled water
Blood type AB	Mix equal amounts of preparations from type A and type B above and place in bottles that can be capped labeled "Blood type AB."
Blood type O	Use distilled water and place into bottles that can be capped marked "Blood type O." Note: no ppt. will form here with Anti-A or Anti-B above which indicates (simulates) lack of antigens (agglutinogens) A and B

NOTE: Correct labeling of solutions is of critical importance

SOURCE: Sharp and Smalles (1989): 232.

TABLE 2

ARTIFICIAL URINE TEST TO SIMULATE

THE TEST OF PREGNANCY

TABLE 2

ARTIFICIAL URINE TEST TO SIMULATE THE TEST FOR PREGNANCY

MATERIALS	PROCEDURE	SUGGESTIONS
1. Human Chorionic Gonadatropin (HCG), Sigma Chemical Company, St. Louis, MO. 2. Anti Human Chorionic Gondotropin (produced in goats), Miles Laboratories, Elkhart, IN. 3. Human Chorionic Gonadotropin-coated Latex Suspension, Wampole Laboratories, Cranbury, N.J. 4. "Artificial" urine prepared by adding 10 mL of distilled water to the lyophilized HCG described above. The final solution will contain 250 I.U. of HCG and 2.5 mg. of Mannitol/mL. in 0.01M Phosphate buffer, pH 7.2.	1. Place one drop of artificial urine, or control urine (distilled water may be used), within a specified area (circle) of a slide. The circles may be drawn on the slide with a wax pencil about one inch in diameter. 2. Add one drop of anti-HCG serum to the drop of urine. 3. Add one drop of HCG-coated latex particles to the above two drops and spread all three drops over the entire circle with a toothpick. 4. Rock the slide gently for two minutes and observe whether or not agglutination has occurred.	1. Since the latex particles are white, hold the slide over a black background, and hold a light source directly over the slide to facilitate the observations. 2. Have all reagents at room temperature before use. 3. Use a new stirrer for each specimen. 4. Use thoroughly cleaned slides, since traces of detergent or previous specimens adversely affect results. 5. Do not rock the slides for more than two minutes, since evaporation or reagents leads to errors in observations

[SOURCE: RUSSO, (1987): 180-181]

APPENDIXES

APPENDIX A

INFECTED INDIVIDUALS AND

DISEASE TRANSMISSION

APPENDIX A

(Fig. I)

INFECTED PERSON	CONTACTS		
	1	2	3
Kim	Eric	Michelle	Amy
Amy	Robert	Shannon	Kim
Robert	Amy	Angie	Alex
Greg	Barry	Stacey	Angie
Angie	Julie	Robert	Greg
Shannon	Tracy	Amy	Michelle
Michelle	Adam	Kim	Shannon
Alex	Brian	Gary	Robert

Figure 1. Results of a simulation.

Source: Dickey (1989): 364.

APPENDIX A

(Fig. 2)

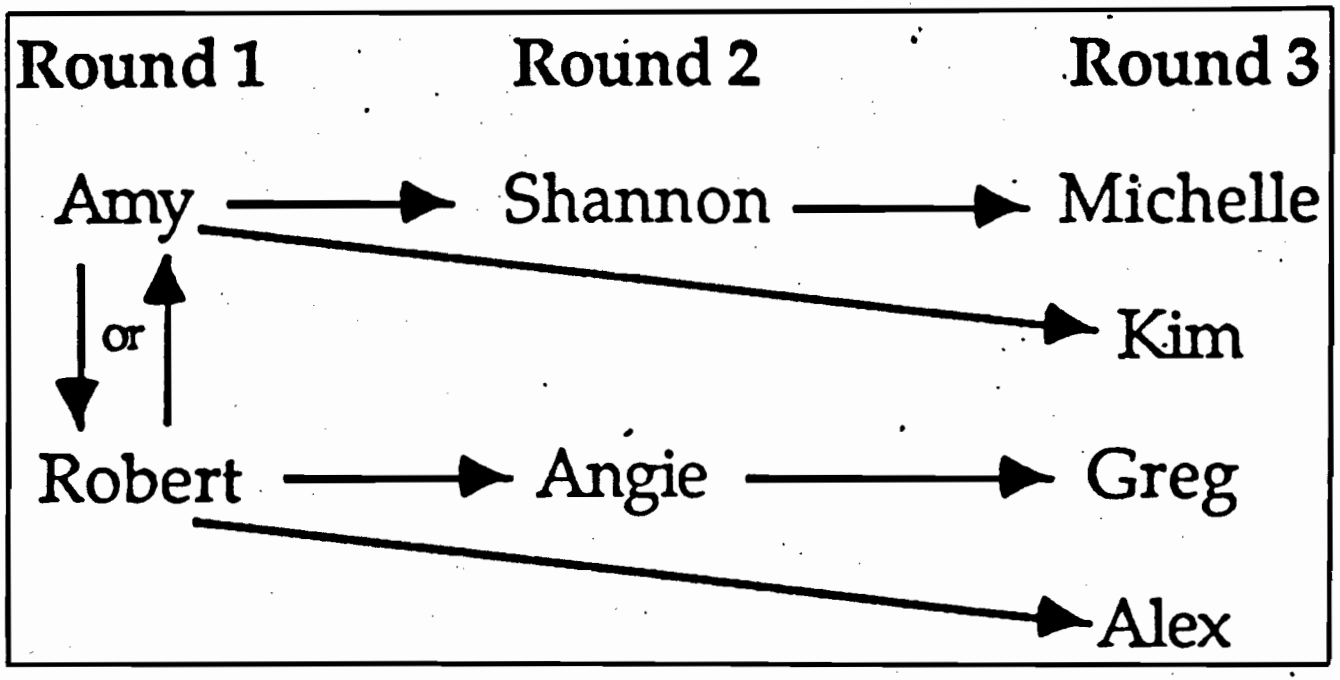


Figure 2. Transmission route.

Source: Dickey (1989): 364.

APPENDIX B

LIST OF SIMULATIONS AND GAMES FOR

QUEBEC ECOLOGY CURRICULUM

APPENDIX B

LIST OF SIMULATIONS AND GAMES RECOMMENDED FOR USE WITH THE QUEBEC ECOLOGY CURRICULUM

TITLE	GAME/SIMULATION	PEDAGOGICAL APPLICATION	CROSS REFERENCE TO QUEBEC CURRICULUM	AGE/GRADE LEVEL	COMPANY/SOURCE AND YEAR
A. LIVING, NON-LIVING					
I. LIVING, NON-LIVING: A GAME OF TWENTY QUESTIONS	A Simple Game	Traits of Living and Non-living	Module: Ecology (Introductory) Subject: Traits of Living and Non-living Page: I9-20	Junior High	Wilson & Mullins. American Biology Teacher,42(9): 566-569. (I980)
B. PREDATION					
2. PREDATOR-PREY	Card-board Game	PREDATION	Module I: Interrelationship Module IV: Circulation of Matter & Energy Subject: Living-living Relationship Predator-prey Population Fluctuations Page: 22, 44	Junior High High School	Urban System Inc. I033-Massachusetts Avenue Cambridge, Mass. (I970)
3. SHARK	Computer Simulation	Predation	Module I: Interrelationship Subject: Living-living Relationships	Junior High High School	Worth Publishing New York, USA (I989)
C. NATURAL RESOURCES					
4. ECOLOGY: THE GAME OF MAN & NATURE	Card Game	Protection of Natural Resources	Module I: Interrelationship ModuleII: Functions of Producers Module 3: Functions of Consumers Subject: Environmental Degradation and over exploitation of Plants & Animals Pages: 24, 29 35	Junior High High School	Urban System Inc. I033-Massachusetts Avenue Cambridge, Mass (I970)

5. NO DAM ACTION: AN ECOLOGY-WATER RESOURCE SIMULATION	Interactive Simulation	Resource Utilization	Module I: Interrelationships Subject: Depletion of Resources Page: 24	Junior High High School	Instructional Simulations Inc. 2I47-University Ave. St.Paul, Minnesota (I970)

D. POLLUTION

6. AIR POLLUTION	Computer Simulation	Air Pollution	Module I: Interrelationships Subject: Pollution Page 24	Junior High High School	Educational Materials and Equipment Company Box-I7 Pelham, New York. (I986)
7. SMOG	Card Game	Air Pollution	Module I: Interrelationships Subject: Pollution Page: 24	Junior High High School	Urban System Inc. I033-Massachusetts Ave. Cambridge, Mass. (I970)
8. DIRTY WATER	Card Game	Water Pollution	Module I: Interrelationships Subject: Polluting Agents and Pollution Page: 22, 24	Grades 4-6 Junior High High School	Digital Equipment Corp. I46-Main Street Maynard, Mass. (I970)
9. WATER POLLUTION	Computer Simulation	Environmental Degradation	Module I: Interrelationships Subject: Pollution Page: 24	I2-I8 Years	Education Materials and Equipmqnt Co. Box-I7 Pelham, New York (1986)
I0. POLLUTION GAME	Board Game	Environmental Degradation	Module I: Interrelationships Subject: Pollution Page: 24	Junior High	Houghton Miffin Co. II0-Tremont Street Boston, Mass. (I970)
II. POLLUTION	Card Game	Environmental Degradation	Module I: Interrelationships Subject: Pollution Page: 24	Junior High	Curriculum Centre Wellesley School I2- Seaward Road WellesleyHills Massachusetta, (I970)

I2. SACRIFICE	Computer Simulation	Environmental Degradation	Module I: Subject: Page:	Inter Relationships Pollution 24	Junior High High School	David G. Sparks Publisher Educational Ventures Inc. 209 - Court Street Middleton, Connecticut (I97I)
I3. RECYCLING LOGIC	Computer Simulation	Pollution: Control Measures	Module IV: Subject: Page:	Circulation of Matter and Energy Recycling 39	6-I2 Years	Sunburst Communications 39-Washington Avenue Pleasantville, New York, USA (I988)
E. PLANTS						
I4. COMPUTER INVESTI-GATIONS: PLANT GROWTH	Computer Simulation	Plant Growth Requirements	Module II: Subject: Page:	Functions of Producers Non-living Elements Needed for Plant Growth 25	7-I2 Years	Focus Media 839 - Stewart Avenue Garden City New York, USA (I989)
I5. TRANSPIRATION	Computer Simulation	Role of Leaves in Water Loss	Module II: Subject: Page:	Functions of Producers Role of Leaves in Plant Life 27	I4-I8 Years	Longman Microsoftwares Longman Resource Unit 33-35 Tanner Road York, United Kingdom (I979)
I6. DESIGNING BLUE-PRINTS FOR GREEN PLANTS	Computer Simulation	Plant Cell Processes: Absorption Growth and Storage Respiration Photosynthesis Transport of Materials and Support	Module II: Subject: Page:	Functions of Producers Life of a Tree 27	Middle and Secondary Level	W.K. Bradford Publishing Box - I355 Concord, Main (I989)

I7. COMPETE	Computer Simulation	Plant Interaction in Single and Mixed Cultures	Module II: Functions of Producers Subject: Principles Governing Plant's Use of Time and Space Page: 27	Junior High High School	Conduit Box - 388 Iowa City Iowa, USA (I983)
I8. SEEDLING	Computer Simulation	Plant Competition and Physiology	Module II: Functions of Producers Subject: Growth Assimilation Transpiration Page: 27	Junior High High School	Worth Publishings New York, USA (I989)
F. FOOD CHAINS					
I9. ODELL LAKE ECOLOGY	Computer Simulation	Food Chains	Module IV: Circulation of Matter and Energy Subject: Food Chains Page: 38	Grades 4-7	Minnesota Educational Computing Consortium 2520-Broadway Drive St.Paul, Minnesota (I983)
G. POPULATION					
20. PLANKTON	Computer Simulation Game	Population	Module IV: Circulation of Matter and Subject: Population Fluctuations Pages: 40 - 4I	Junior High High School	Worth Publishings New York, USA (I989)
2I. THAT,S LIFE: FIELD ECOLOGY	Computer Simulation	Predator-prey: Population Control	Module IV: Circulation of Matter and Enery S Subject: Population Fluctuation and Carrying Capacity Page: 40	Grades-7 and Up	Mindscape Dundee Road Northbrook, Illinois Illinois, USA (I989)

APPENDIX C

LIST OF SIMULATIONS AND GAMES FOR QUEBEC HUMAN BIOLOGY CURRICULUM

APPENDIX C

LIST OF SIMULATIONS AND GAMES RECOMMENDED FOR USE WITH THE QUEBEC HUMAN BIOLOGY CURRICULUM

TITLE	GAMES/SIMULATION	PEDAGOGICAL APPLICATION	CROSS REFERENCE TO QUEBEC CURRICULUM	AGE/GRADE LEVEL	COMPANY/SOURCE & YEAR
A. CARDIOVASCULAR SYSTEM					
1. HEART PROBE	Computer Game and Simulation	Heart Structure and Function	Module I: Nutrition Subject: Anatomy and Physiology of Circulatory System Pages: 19-20	Grades 6-12	Bio-Soft, Box 7294 Winter Haven Florida 33883 (1989)
2. HEART ANATOMY AND PHYSIOLOGY	Graphic Computer Simulation	Heart Structure and Physiology	Module I: Nutrition Subject: Anatomy and Physiology of Circulatory System Pages: 19-20	Grades 4-8	American Heart Association 7230 Greenville Avenue Dallas, Texas 75231 (1989)
3. HEART MEDLEY	Computer Games	Heart Diseases	Module I: Nutrition Subject: Health and Cardiovascular System Page: 21	Grades 4-8	American Heart Association 7320 Greenville Avenue Dallas, Texas 75231 (1989)
4. ALIEN	Microcomputer Simulation	Cardio-Pulmonary Physiology	Module I: Nutrition Subject: Physiology of Circulatory System Page: 20	Secondary	Worth Publishing New York (1989)
5. EVERYBODY WINS: AN ORAL ASSIGNMENT LOTTERY	Non-computer Game	Human Cardiovascular System: Blood Vessels	Module I: Nutrition Subject: Anatomy and Physiology of Circulatory System Pages: 19-20	Secondary	Sguitieri, L. (19886) American Biology Teacher, 48(7):430-431. (1986)
6. HUMAN CIRCULATORY SYSTEM	Computer Simulation	Human Circulatory System: Pulmonary Vs. Systemic Circulation	Module I: Nutrition Subject: Physiology of Respiratory System Page: 18	Grades 7-9	Educational Materials and Equipment, Box-2805 Old Mill Plain Road Danbury, CT 06813-2805 (1988).

7. **BLOOD PRESSURE BUMMY**	Card Game	Human Circulatory System: Alteration and Stability	Module I: Subject: Page: 2I	Nutrition Health and Cardiovascular System	Secondary to College	Walsh, J. (1986). American Biology Teacher, 48(5):300-317. (1986).
8. **BLOOD TYPE TEST**	Non-computer Simulation	Blood-typing An Antigen-Antibody Reaction	Module I: Subject: Page: 20	Nutrition Physiology of Circulatory System	Secondary & College	Sharp & Smailes (1989) American Biology Teacher, 51(4):232-233 (1989)
B. DIGESTION:						
9. **METABOLIC MARATHON**	Computer Game	Major Metabolic Pathways	Module I: Subject: Page: 22	Nutrition Cell Activities	Secondary & college	Compress, A Division of Wadsworth Inc. Box 102-Wentworth NH 02382 USA (1986)
10. **HUMAN ENERGY EXPENDITURE**	Computer Simulation	Food Energy Intake and Energy Expenditure	Module I: Subject: Pages: 23-24	Nutrition Utilization of Carbohydrates and Fat	14 years and up	Longman Micro Software Longman Resource Unit 33-35 Tanner Road YORK YOL 1JP UNITED KINGDOM (1979)
11. **LET'S GET PHYSICAL**	Computer Game	Food and Physical Activity	Module I: Subject: Page: 24	Nutrition Balance Between Food - Intake and Activities	Grade 6-Adult	Orange Cherry Software, Box-1390, Pound Ridge, NY 10576 (1988)
C. LOCOMOTOR SYSTEM						
12. **SKELETAL SYSTEM**	Computer Simulation	Skeletal System	Module II: Subject: Page: 33-34	Relationships The Skeleton	10-years & up	Brain Bank Inc. 220 Fifth Avenue New York, NY 10001 (1983)

D. NERVOUS SYSTEM

13.	EXPLORING YOUR BRAIN	Computer Simulation	Human Nervous System: Brain Structure, Function & Malfunction	Module II: Subject: Page: 32	Relationships Nervous System	12-18 Years	Epilepsy Foundation of America 4345 Garden City Drive Landover, MD 20785 (1983)

E. REPRODUCTIVE SYSTEM

14.	CYCLE	Computer Simulation	Reproduction: Menstrual Cycle	Module III: Sujbect: Page: 37	Reproduction Menstrual Cycle	Secondary to College	Worth Publishing New York (1989)
15.	ARTIFICIAL URINE TEST	Non-computer Simulation	Principle of Pregnancy Test	Module III: Subject: Page: 42	Reproduction Pregnancy	14 and up	Russo, A.J. (1987) American Biology Teacher, 49(3):180-181 (1987)
16.	ALCOHOL AND PREGNANCY	Computer Simulation Game	Fetal Alcohol Syndrome	Module III: Subject: Page: 42	Reproduction Pregnancy	Grade 7 & up	Student Awareness Softwar Box 18134 Portland, OR. 97213 (1989).
17.	AGGLUTININ TEST FOR PREGNANCY AND SYPHILIS	Non-Computer Simulation	Pregnancy Sexually-Transmitted Diseases	Module III: Subject: Page: 42,43-44	Reproduction (i) Pregnancy (ii) Syphilis	14 and up	Miller J.E. (1987) American Biology Teacher, 49(5):291-292. (1987)
18.	SIMULATION OF DISEASE TRANSMISSION	Non-Computer Simulation Game	Sexually-Transmitted Diseases	Module III: Subject: Page: 43	Reproduction Pathological Consequences of Sexual Intercourse	14 and up	Dickey, J.L. (1989) American Biology Teacher, 51(6): 365-365. (1989)

F. SENSE ORGANS

19.	SPECIAL SENSES: VOL. I. THE EYE	Computer Simulation	Human Eye: Anatomy, Optics Mechanism of Vision	Module III: Subject: Pages: 27,28	Relationships Anatomy of Eye Physiology of Eye	14 and up	Compress. A Division of Wadsworth Box 102, Wentworth, NH 03282 (1986)
20.	SPECIAL SENSES: Vol. II: THE EAR	Computer Simulation	Human Ear: Anatomy and Mechanics of Hearing	Module Subject: Page: 29	Relationships Anatomy and Physiology of Ear	14 and up	Compress, A Division of Wadsworth Inc. Box - 102 Wentworth, NH 03282, USA (1986)

G. HUMAN BODY

21.	ANATOMY CHALLENGE	Interactive Computer Game	Human Anatomy: Ten Anatomical Categories Included	Module I: Module II: Module III: Subject: Pages: 16,18,19,32,33,35,36 & 38-39	Nutrition Relationships Reproduction Anatomy of Digestive System Anatomy of Respiratory System Anatomy of Circulatory System Anatomy of Musculatory, Nervous and Reproductive System	14 and up	Island Software Box-300 Lake Grove, New York (1986)
22.	HUMAN BODY: AN OVERVIEW	Graphic Computer Simulation	Human Body: Introduction to Six Major Systems	Module I: Module II: Subject:	Nutrition Relationship Digestive, Respiratory, Nervous Skeletal and Muscular Pages: 16, 18, 19, 32, 33 & 35	14 and up	Brain Bank Inc. 220 Fifth Avenue New York N.Y. 10001 (1988)
23.	THAT'S LIFE: HUMAN BODY EXPLORATION	Computer Simulation	Human Body: Seven Organs Explored	Module I: Module II: Subject:	Nutrition Relationships	14 and up	Mindscape Inc. 3444 Dundee Rd. Northbrook, Illinois 6006 (1988)
24.	ADVENTURE IN FLESH	Computer Simulation	Human Body: Ten Ailments	Module I: Subject: Page: 17, 18-19, 21, 28-29, 30 & 31	Nutrition Human Body Ailments	14 and up	Krell Software 130 Stoneybrook Rd Stoneybrook, NY 11790 (1987)

APPENDIX D

EXCERPTS FROM QUEBEC ECOLOGY CURRICULUM

(1983)

6. Content

Ecology (Introduction)

Skill

Attitude: To be aware of the general characteristics of environmental phenomena.

Skill		Learning Content
	* T.O. 0.1 **To give** a definition of the word "ecology."	Science which examines all the relationships between living things and their environment. A biological science which seeks to learn about life.
	* 0.1.1 **To give** possible interpretations of the expression "ecological relationship."	Relationship, need for, dependent upon, influences. . . .
	* 0.1.2 **To give** a simple definition of the expression "natural environment."	A unit of nature which comprises living and nonliving things involved in a variety of activities.
	* 0.1.3 **To give** a definition of the expression "surrounding community."	A natural or artificial environment which includes man.
To be able to recognize the limitations of sensory perceptions.	* T.O. 0.2 **To give** a modified definition of the expression "scientific method."	A scientific method of work which involves carrying out specific activities to lead to discovery, or an intellectual approach which involves carrying out a series of activities to lead to the solution of a particular problem.
	0.2.1 **To name** activities which would combine to create a suitable working method for ecology.	Observation, experimentation, consultation or reference material, communication.
To know how to record similar and dissimilar characteristics.	T.O. 0.3 **To identify** the members of the living part of the environment.	Producer, consumer, decomposer.
	0.3.1 **To name** the characteristics of a living organism.	Capable of: movement, feeding, growth, reproduction, respiration.

* This objective may be introduced at any time.

0.3.2	**To distinguish** between living and nonliving things.	
0.3.3	**To classify** about twenty given things into two categories: living and non-living.	
0.3.4	**To give** a simple definition of the word "producer."	A living organism which utilizes non-living substances and transforms them into living matter.
0.3.5	**To give** a simple definition of the word "consumer."	A living organism which seeks and utilizes food for its activities and movements.
0.3.6	**To give** a simple definition of the word "decomposer."	A living organism which utilizes living matter and transforms it into non-living matter.
T.O. 0.4	**To give** a simple definition of the word "species."	Two organisms are of the same species if male and female can reproduce and produce viable offspring similar to themselves.
0.4.1	**To distinguish**, among plant specimens, those whose leaves are simple or compound, smooth or serrated, lobed or unlobed.	
0.4.2	**To distinguish**, among animal specimens, those that have different profiles of the head, limbs, or body.	

1° Interrelationships

GENERAL OBJECTIVE: TO KNOW VARIOUS FORMS AND FUNCTIONS OF LIFE

Skill: To develop different abilities (dexterity).

Attitude: To have a sense of wonder about environmental phenomena (sense of curiosity).

Skill		Learning Content
	**Attitude:** To be aware of the general characteristics of environmental phenomena.	
To know how to record the specific characteristics of a phenomenon.	T.O. 1.1 **To distinguish** the different types of interactions that occur in the environment.	Living/living relationships. Nonliving/living relationships. Living/nonliving relationships
	1.1.1 **To identify** among examples, a living/living relationship.	
	1.1.2 **To identify** among examples, a nonliving/living relationship.	
	1.1.3 **To identify** among examples, a living/nonliving relationship.	
	1.1.4 **To define** the word "phenomenon"	A form or function in the environment
	Attitude: To be willing to take an investigative approach	
To know how to take a measurement. **To know how to take** a precise reading on an instrument. **To know how to follow** a procedure. **To know how to construct** a histogram or graph.	T.O. 1.2 **To name** the characteristics of nonliving elements	
	1.2.1 **To identify** the properties of air.	Temperature, wind, humidity.
	1.2.2 **To identify** the properties of water.	Temperature, transparency, flow.
	1.2.3 **To identify** the properties of light.	Luminosity, reflection.
	1.2.4 **To identify** the properties of soil.	Air, water, organic matter, mineral salts.
	1.2.5 **To determine** the percentage of water retained in soil.	
	1.2.6 **To determine** the percentage of organic matter in soil.	
	1.2.7 **To determine** the percentage of air retained in soil.	
	1.2.8 **To determine** the presence or absence of mineral salts in soil.	

T.O. 1.3	**To give** the reasons why the presence of organic matter in the soil is important in plant cultivation.	Water retention, soil aeration, soil enrichment, . . .
1.3.1	**To determine**, by means of an experiment, the water retention capacity of organic matter (humus).	
T.O. 1.4	**To identify** the harmful effects that various polluting agents suspended in the air or in water can have on man's health.	
1.4.1	**To identify** one of the differences between "natural air" and "polluted air."	Presence of foreign particles, . . .
1.4.2	**To determine** the qualitative value of different air samples collected around the school or elsewhere.	
1.4.3	**To identify** one of the differences between "natural water and "polluted water."	Presence of foreign particles, . . .
1.4.4	**To determine** the qualitative value of different water samples collected in the area.	
1.4.5	**To identify** toxic substances which cause pollution if they are present in the air or in water.	

Attitude: To be willing to follow a structured approach in consulting reference material.

To know how to select the passage in a reference material which answers a specific question.

T.O. 1.5	**To identify**, from examples, phenomena of living/living relationships.	Predation, parasitism, commensalism, mutualism, . . .
1.5.1	**To illustrate** some phenomena of predation.	
1.5.2	**To distinguish** between prey and predator.	
1.5.3	**To illustrate** some phenomena of parasitism.	
1.5.4	**To distinguish** between host and parasite.	
1.5.5	**To illustrate** some phenomena of commensalism.	
1.5.6	**To illustrate** one phenomenon of competition.	
1.5.7	**To illustrate** one phenomenon of mutualism.	

T.O. 1.6	**To identify**, from examples, phenomena of nonliving/living relationships	Windfalls, withering, heliotropism geotropism, cracks caused by frost, contamination.
1.6.1	**To name** some of the natural phenomena which can cause a windfall.	Tree(s) naturally felled by the wind, the weight of snow, frost, running water, earth tremors, or age
1.6.2	**To name** some of the phenomena which can cause withering of trees or plants.	Heat, cold, wind, water.
1.6.3	**To give** a simple reason for the phenomenon of heliotropism in a given plant.	Attraction to light.
1.6.4	**To give** a simple reason for the phenomenon of geotropism in a given plant.	Gravity.
1.6.5	**To give** a simple reason for the phenomenon of hydrotropism.	Attraction to water.
T.O. 1.7	**To identify**, from examples, phenomena of living/nonliving relationships	Burrowing, engineering skill, periodicity, migration.
1.7.1	**To give** a simple reason for the burrowing action of a given animal	Hiding place, search for food.
1.7.2	**To give** a simple reason for a phenomenon of engineering of a given animal.	
1.7.3	**To name** factors which contribute to the falling of leaves in autumn.	Light, temperature.
1.7.4	**To name** factors which contribute to the migration of a given bird.	Light, food, temperature.
T.O. 1.8	**To identify**, from examples, phenomena of living/human relationships.	Hunting, fishing, agriculture, breeding and raising livestock, forestry.
1.8.1	**To name** species of animals taken from the sea for use as food.	
1.8.2	**To name** species of trees commonly used in paper production.	

1.8.3 **To name** species of trees commonly used in construction.

1.8.4 **To identify** acts of vandalism which occur in public parks.

Damage to the bark of trees, bird hunting, . . .

T.O. 1.9	**To identify**, from examples, phenomena of nonliving/human relationships.

Intoxication, diseases, . . .

1.9.1 **To name** substances which may be dangerous to health if inhaled.

Insecticides, herbicides, industrial wastes, . . .

1.9.2 **To name** substances which may be dangerous to health if absorbed.

T.O. 1.10	**To identify**, from examples, phenomena of human/nonliving relationships.

Industrialization (construction, manufacture), mining, . . .

1.10.1 **To name** mining products used in home construction.

Attitude: To be willing to re-examine objectively the ways in which he uses environmental resources.

To know how to solve a problem through discussion or dialogue.

T.O. 1.11	**To investigate** ways in which man can benefit from the use of water, air, soil, fauna, and flora.

Activities essential to our way of life:

— use of soil (agriculture, livestock, . . .)

— use of green spaces (recreation, leisure, . . .)

T.O. 1.12	**To investigate** the risks and dangers involved in detrimental use of water, air, and soil.

Pollution, contamination, depletion of resources, environmental degradation, . . .

2° The Functions of Producers

GENERAL OBJECTIVE: TO KNOW THE PLANT AS AN ORGANISM WHOSE ROLE IN NATURE IS THAT OF PRODUCER.

Skill: To develop different abilities (dexterity).

Attitude: To be interested in, and aware of, plants and trees (sense of curiosity).

Skill		Learning Content
	**Attitude:** To be aware of the general characteristics of environmental phenomena.	
To know how to record the specific characteristics of a phenomenon.	T.O. 2.1 **To identify**, from examples, different forms of plant behaviour.	Heliotropism, phototropism, geotropism, hydrotropism, . . .
	2.1.1 **To describe** the response of a plant (leaf and stem) to light.	
	2.1.2 **To describe** the response of a plant (root) to soil.	
	2.1.3 **To describe** the response of a plant (root) to water.	
	**Attitude:** To be able to ask himself questions.	
To know how to state assumptions on the basis of a demonstration or set-up.	T.O. 2.2 **To identify** the nonliving elements required for the process of assimilation in plants.	Carbon dioxide, water, mineral salts, light.
	2.2.1 **To explain** the importance of water for a green plant.	
	2.2.2 **To explain** the importance of light for a green plant.	
	2.2.3 **To explain** the importance of carbon dioxide for a green plant.	
	2.2.4 **To explain** the importance for a green plant of mineral salts dissolved in water.	

Attitude: To be willing to take an investigative approach.

To know how to choose a simple procedure to verify a given assumption.

To know how to list the steps of an experiment in the correct order.

T.O. 2.3 **To explain**, in a simple manner, the function of chlorophyll.

Water + CO_2 + light ⟶ sugar + oxygen.

2.3.1 **To discover**, by means of an experiment, a source of oxygen production.

2.3.2 **To discover**, by means of an experiment, the presence of energy in a plant.

2.3.3 **To discover**, by means of an experiment, the influence of light on the production of carbon dioxide and oxygen in a plant.,

2.3.4 **To discover**, by means of an experiment, the influence of light on leaf colouration.

2.3.5 **To discover**, by means of an experiment, the role of the stem and the root in absorbing water.

2.3.6 **To discover**, by means of an experiment, the presence of chlorophyll in a leaf.

2.3.7 **To discover**, by means of an experiment, the presence of sugar (starch) in a plant.

2.3.8 **To discover**, by means of an experiment, the presence of mineral salts in a plant.

T.O. 2.4 **To explain**, in a simple manner, the general reaction for respiration.

Sugar + oxygen ⟶ carbon dioxide + water + heat.

2.4.1 **To discover**, by means of an experiment, the presence of water vapor and carbon dioxide.

2.4.2 **To discover**, by means of an experiment, a source of carbon dioxide production.

2.4.3 **To give** a simple explanation of how wood burns.

Wood + high heat ⟶ creosote
creosote + oxygen ⟶ flame + + smoke + water vapor.

2.4.4 **To discover**, by means of an experiment, the phenomenon of transpiration in a plant.

Attitude: To be willing to take an investigative approach.

To know how to coordinate observations made over a period of time.

To know how to construct a graph based on two variables.

T.O. 2.5	**To identify** the main stages in the germination and growth of a plant.

2.5.1 **To discover**, by means of an experiment, the importance of water and light to the growth of a plant.

2.5.2 **To discover**, by means of an experiment, the role of cotyledons during the germination of a bean.

2.5.3 **To discover**, by means of an experiment, the effect of a "hormone" on the growth of a plant.

2.5.4 **To identify** the following parts in a bean that has been cut in half: embyro, plumule, . . .

Attitude: To be willing to follow a structured approach in consulting reference material.

To know how to answer a specific question with the aid of reference material (books, films, . . .)

T.O. 2.6	**To identify** the principles which govern a given plant's use of time and space.	Growth, reproduction, energy assimilation, adaptation to climate, competition, . . .
2.6.1	**To explain** the role of leaves, flowers, roots, and the stem in the growing cycle of a given plant.	Absorption, respiration, transpiration, Absorption of water, Food storage or reserve in the form of wood.
2.6.2	**To explain** the role of colonizing plants in a given environment.	Ensure plant succession, . . .
T.O. 2.7	**To explain**, using resource material, the reproduction activities of a given flowering plant.	Pollination, fruit formation, seed dispersal, . . .
2.7.1	**To explain** the role of the flower in plant reproduction.	Fertilization, fruit formation, . . .

2.7.2	**To describe** the simple phenomenon of fertilization of a flowering plant.	
2.7.3	**To identify** pollinating agents.	Wind, insects, man, . . .
2.7.4	**To identify** seed-dispersing agents.	Wind, animals, insects, water, . . .
T.O. 2.8	**To identify** ways in which agricultural and forestry activities benefit the community.	
2.8.1	**To identify** the prime source of energy on earth.	
2.8.2	**To identify** important sources of carbon dioxide production in a given community.	Fuel-burning equipment, human respiration, . . .
2.8.3	**To identify** important sources of oxygen in a given community.	Plants, trees, . . .
2.8.4	**To identify** the main steps in the cultivation of cereal plants.	Soil preparation, sowing, plant maintenance and protection, harvesting.
2.8.5	**To identify** the edible part(s) of plants, from a list of plants.	
2.8.6	**To name** plants produced on a farm which do not need to be processed before consumption.	
2.8.7	**To name** plants produced on a farm which have been processed for consumption.	
2.8.8	**To draw up a list** of products which man obtains from a given vegetable or fruit.	
2.8.9	**To draw up a list** of products which man obtains from a given tree or plant.	

Attitude: To be willing to re-examine objectively the ways in which he uses plants to satisfy his needs.

To know how to solve a problem through discussion or dialogue.	T.O. 2.9 **To investigate** ways in which man can benefit from the use of plants.	Improved quality of life, satisfaction of needs: food, clothing, construction, medication, decoration, . . .
	T.O. 2.10 **To investigate** the risks and dangers involved in excessive exploitation of plants.	Environmental degradation, depletion of soil minerals, over-production.

3° The Functions of Consumers

GENERAL OBJECTIVE: TO KNOW THE ANIMAL AS AN ORGANISM WHOSE ROLE IN NATURE IS THAT OF CONSUMER.

Skill: To develop different abilities (dexterity).

Attitude: To be interested in, and aware of, all animals, large and small (sense of curiosity).

Skill

To know how to record the specific characteristics of a phenomenon.

Attitude: To be aware of the general characteristics of environmental phenomena.

Learning Content

T.O. 3.1 **To identify**, from examples, social interactions between individual members of a given population.

Relationships within a group: dominance, hierarchy, . . .

Parent-offspring relationships: care, feeding, games, learning, . . .

Male-female relationships: selection, territory, . . .

3.1.1 **To describe** a phenomenon of dominance.

3.1.2 **To describe** a phenomenon of hierarchical order.

3.1.3 **To identify** ways in which the individual members benefit from social communication within a population.

Identification of self to others, revealing of intentions, . . .

3.1.4 **To describe** a phenomenon of parent-offspring relationships.

3.1.5 **To describe** a phenomenon of male-female relationships.

3.1.6 **To define** the word "population."

Group of individuals of the same species living in a specific location.

T.O. 3.2 **To identify**, from examples, different social relationships between humans.

Cooperation, competition, independence, exploitation, . . .

3.2.1 **To name** some of the advantages of community life for the human species.

Attitude: To be able to ask himself questions.

To know how to state assumptions on the basis of a demonstration or set-up.

T.O. 3.3 **To classify** examples of different cyclical activities observed for given animals, according to daily, seasonal, and annual rhythms.

Daily activities: search for food, rest, grooming, cry or song, . . .

Seasonal activities: change of habitat, change of food, change in appearance.

Annual activities: mating, reproduction.

3.3.1 **To name** characteristic movements made by a given animal in its search for food. — Using sense of smell, using sense of sight.

3.3.2 **To name** ritual grooming patterns of a given animal. — Licking of whiskers, abdomen, . .

3.3.3 **To name** characteristic movements made by a given animal when exploring a new environment. — Mobile exploration, stationary exploration, . . .

3.3.4 **To name** characteristic movements made by a given animal to maintain balance. — Balance or counterbalance, using tail or nose, . . .

3.3.5 **To name** characteristic movements made by given animals during migration. — Movement pattern, position of young in a herd, position of dominant animals in a herd, . . .

3.3.6 **To name** characteristic reactions of two animals of the same species when they meet. — Acceptance, mating, rejection, fighting, . . .

3.3.7 **To name** characteristic reactions of a given cold-blooded animal during hibernation. — Sluggishness, slower respiratory rhythm, . . .

3.3.8 **To name** ways in which warm-blooded animals resist winter. — Migration, sleep, thickening of fur, . . .

3.3.9 **To distinguish** between "hibernation" and "wintering."

Attitude: To be willing to take an investigative approach.

To know how to choose a simple procedure to verify assumptions.	T.O. 3.4 **To identify** ways in which learning may influence the behaviour of a given animal.	Learning: modifies instinctive actions, brings about observable changes, improves certain other learned actions.
	3.4.1 **To distinguish** "innate behaviour" and "learned behaviour."	Innate behaviour: instinctive action inherent at birth. Learned behaviour: action learned from experience.
	3.4.2 **To identify** modes of learning.	Repetition, trial and error, copying, . . .
	3.4.3 **To discover**, by means of an experiment, the learning capacity of a given animal confronted with choices (e.g.: colours, obstacles, . . .).	
	3.4.4 **To give** the meaning of the word "stimulus" when it is used in connection with a learning activity.	Trigger, excitation in response to signals, . . .
	3.4.5 **To discover**, by means of an experiment, a given animal's preference for light or darkness.	Attraction or flight, . . .
	3.4.6 **To discover**, by means of an experiment, a given animal's preference for high or low temperatures.	
	3.4.7 **To discover**, by means of an experiment, a given animal's preference for a dry or wet environment.	
	3.4.8 **To discover**, by means of an experiment, a given animal's preference for a complex or simple environment.	Example of a complex environment: a cage filled with obstacles. Example of a simple environment: an empty cage.

Attitude: To be willing to take an investigative approach.

To know how to compile data over a period of time.

T.O. 3.5 **To identify** the different parts of an animal's body.

To know how to predict the shape of a graph.

3.5.1 **To identify** factors which affect the growth of an animal. — Abundance or deficiency of food or water.

3.5.2 **To discover**, by means of an experiment, the importance of food and water to the growth of an animal.

Attitude: To be willing to follow a structured approach in consulting reference material.

To know how to answer a question with the aid of reference material (books, films, . . .)

T.O. 3.6 **To identify** the principles which govern a given animal's occupation of space. — Resources, economy of energy, complete familiarity with living space, . . .

3.6.1 **To define** the term "living space." — The home: the region the animal knows very well and spends time in each day.

3.6.2 **To identify** the elements that make up the living space of a given animal. — 1 main shelter, 3-4 secondary shelters, sources of drinking water, adequate food supply, pathways, . . .

3.6.3 **To describe** the shelter of a given species. — Cave, burrow, debris, hole, beaver lodge, nest, . . .

3.6.4 **To associate** given species with their shelters.

3.6.5 **To define** the word "territory." — Space which an animal will defend to the limit.

3.6.6 **To name** a means used by a given animal to establish his territory. — Cry, song, marking, fighting, . . .

3.6.7	**To indicate**, using a given book, the features of the habitat of a given animal.	Habitat: shelter, territory, living space.
3.6.8	**To associate** a given type of movement with a body part.	Webbed feet = swimming hooves = running fingers = gripping wings = flying powerful hind legs = jumping
T.O. 3.7	**To identify**, using a book, activities which show how a given animal's time is organized.	Daily activities, seasonal activities, annual activities
3.7.1	**To associate** various forms of beak or mouth with a given food diet.	
3.7.2	**To give** some of the elements which characterize the food diet of: 1. a herbivore 2. a carnivore 3. a decomposer or scavenger 4. an omnivore.	Foods: meat, fruit, vegetables, carcasses, . . .
3.7.3	**To distinguish** the mouth of a carnivore, the mouth of a herbivore (ruminant), and the mouth of a herbivore (gnawer).	
3.7.4	**To distinguish** the beak of a carnivorous bird (predator) and the beak of an insect-eating bird (or the beak of a granivore and the beak of an omnivore).	
3.7.5	**To differentiate** between bird reproduction and mammalian reproduction.	
3.7.6	**To describe** the behaviour of a given animal in a particular situation.	Displaying, mating, grooming, . . .
3.7.7	**To name** three important stages in satisfying a specific need (e.g.: eating).	Stages: 1. search, 2. accomplishment or satisfaction, 3. rest.
T.O. 3.8	**To identify** factors linked to human activity which have, or could have, a positive or negative effect on fauna.	
3.8.1	**To identify** animal species saved from extinction by man's intervention.	
3.8.2	**To identify** endangered animal species.	

	3.8.3 **To identify** negative actions which could endanger a given species.	Uncontrolled hunting, pollution, destruction of habitats, . . .
	3.8.4 **To name** positive factors which could assure the survival of a given species.	Wildlife reserves, scientific studies, . . .
	3.8.5 **To draw** up a list of products obtained from the carcass of a given animal.	
	**Attitude:** To be willing to re-examine objectively the ways in which he uses animals to satisfy his needs.	
To know how to solve a problem through discussion or dialogue.	T.O. 3.9 **To investigate** the ways in which man can benefit from the use of animals.	Improved quality of life, food, clothing, recreation, economic investment.
	T.O. 3.10 **To investigate** the risks and dangers involved in excessive exploitation of animals.	Decrease in animal population, overproduction, overexploitation, . . .

4° Circulation of Matter and Energy

GENERAL OBJECTIVE: TO KNOW THAT IN NATURE NOTHING IS LOST AND NOTHING IS CREATED.

Skill: To develop different abilities (resourcefulness).

Attitude: To be aware of the balance in nature (understanding of nature).

Skill | **Learning Content**

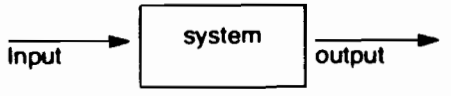
Attitude: To be aware of the details of environmental phenomena.

To be able to record characteristics for making comparisons.

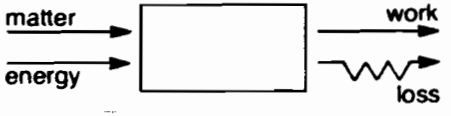
T.O. 4.1 **To explain**, in a simple manner, the general energy transfer reaction.

Energy = work + heat

4.1.1 **To identify** the inputs and outputs of a given system.



4.1.2 **To identify** the components of a simplified model of a system.



4.1.3 **To compare** an internal combustion engine and a living organism, using a model of a system.

4.1.4 **To identify** the components of a natural closed system e.g., an aquarium.

4.1.5 **To identify** the components of an open system e.g., a lake.

Attitude: To be willing to take an investigative approach.

To know how to interpret the results of an experiment.

T.O. 4.2 **To name** the basic principles of energy transfer.

Energy changes from one form to another. There is always loss of heat during a transfer of energy.

4.2.1 **To discover**, by means of an experiment, "the different forms of energy loss in an animal."

	4.2.2 **To give** a simple definition of the word "biomass."	Accumulated matter in one or more organisms at a given time.
	4.2.3 **To determine**, in percentage form, the net productivity of an organism from given data on gross productivity and measurable loss.	Gross productivity – loss = net productivity. (The net productivity is estimated at approximately 10%).

Attitude: To be willing to follow a structured approach in consulting reference material.

To know how to diagram correctly the steps in a process.

To know how to use symbols.

T.O. 4.3	**To define** the expression "circulation of matter."	Circulation = exchange or transfer.
	4.3.1 **To identify** the following phenomena on a diagram of the water cycle: evaporation, transpiration, condensation, precipitation, run-off.	
	4.3.2 **To identify** the following phases on a diagram of the carbon cycle: release of carbon dioxide, photosynthesis, respiration, release of oxygen, sugar production (foods).	
	4.3.3 **To give** a simple definition of the word "respiration."	
	4.3.4 **To show** the relationship between "respiration" and "combustion."	
	4.3.5 **To give** a simple definition of the word "photosynthesis."	"Photo" means "light" "syn" means "with" "thesis" means "putting together."
T.O. 4.4	**To name** substances in which energy is stored.	Natural gas, oil, peat, . . .
	4.4.1 **To identify** sources of energy other than fossil fuels.	Wood, peat, manure, wind, sun, . . .
	4.4.2 **To associate** sources of energy with given needs.	E.g. heating of homes with: coal, oil, natural gas, electricity, . . .

T.O. 4.5 **To identify** the following links on a diagram showing the food chain of a terrestrial environment: producer, herbivore (1st level consumer), carnivore (2nd level consumer), and decomposer (3rd level consumer).

4.5.1 **To give** a working definition of the word "producer." — A green plant which is capable of capturing light energy and transforming it into sugar (chemical energy).

4.5.2 **To give** a working definition of the word "herbivore." — A consumer which is capable of deriving its sustenance from producers (green plants).

4.5.3 **To give** a working definition of the word "carnivore." — A consumer which is capable of deriving its sustenance from either a herbivore or another carnivore.

4.5.4 **To give** a working definition of the word "decomposer." — A consumer which is capable of deriving its sustenance from wastes and carcasses and returning a variety of nonliving matter to the environment.

4.5.5 **To list**, in order, given organisms of a forest environment on a diagram of a food chain.

4.5.6 **To name** organisms that might be hunted by a given predator.

4.5.7 **To define** the word "to need." — To be dependent on. . . .

Attitude: To be willing to follow a structured approach in consulting reference material.

To know how to answer a question, using a table or diagram.

T.O. 4.6 **To identify** the following components on a diagram of an ecological system: energy input, producers, herbivores, carnivores, wastes, decomposers, loss.

4.6.1 **To identify**, among examples, a pyramid based on numbers.

4.6.2 **To identify**, among examples, a pyramid based on mass (according to an estimated 10% productivity).

4.6.3 **To identify** the trophic levels of an environment.

Trophic levels
1. producers
2. primary consumers
3. secondary consumers
4. tertiary consumers

4.6.4 **To compare** the trophic levels of a natural, semi-natural, and artificial environment.

4.6.5 **To determine**, from a model of an ecological system, the biomass of each link in the food chain (based on 10% productivity).

4.6.6 **To define** the word "ecosystem."

Any unit of nature that includes living organisms and nonliving matter which, in interacting, bring about exchanges of matter and energy.

T.O. 4.7 **To give** a definition of the word "recycling."

4.7.1 **To identify** a mechanism for recycling wastes (solid or liquid) on a diagram of a city layout.

4.7.2 **To identify** a mechanism for recycling organic matter on a diagram of a farm layout.

4.7.3 **To identify** sources of energy waste in the form of heat.

T.O. 4.8 **To compare** the food supply systems of a given indigenous population and a given urban population.

4.8.1 **To construct** an energy chain for a given food.

E.g. sun → grass →
cow → milk.

4.8.2 **To represent**, by means of a flowchart, the system for marketing a given food.

Farm → wheat
mill → flour
bakery → bread
grocery store

4.8.3	**To represent**, by means of a flowchart, the input of matter and energy required to market a given food product.	
4.8.4	**To identify** ways in which over-consumption of products is promoted.	Advertising, . . .
T.O. 4.9	**To identify**, on a food chain diagram, the transfer of toxic substances which man has released into the environment.	
4.9.1	**To identify** a way in which man controls the increase of competitive species.	Chemical spraying, . . .
4.9.2	**To identify** a way in which man protects the development of useful species.	Selective spraying, . . .
4.9.3	**To identify** nonbiodegradable substances which can circulate in the food chain.	D.D.T., mercury, . . .
4.9.4	**To identify** techniques used in biological control.	Selected predators, selected parasites, . . .
4.9.5	**To identify** toxic substances which endanger man's health.	Chlorine, cyanide, . . .
4.9.6	**To name** methods suggested for eliminating toxic wastes.	Incineration, solidification, safe burial, . . .
T.O. 4.10	**To explain**, using a table showing the prey-predator relationship, a fluctuation in population at a given time.	Surplus or shortage causes an increase or decrease in population.
4.10.1	**To determine** the density of a population according to the formula $D = N/S$.	D = density, N = number of individuals, S = given space occupied.
4.10.2	**To determine**, from a sample and the formula $N = S \times D$, the number of individuals in a given population.	
4.10.3	**To define** the expression "carrying capacity."	Quantity of food available in a given place.
4.10.4	**To explain** the consequences of too large a population of consumers in a limited space.	Degradation of the habitat, decline in number of individuals, . . .

4.10.5 **To show** the relationship between "carrying capacity" and "population density."

Attitude: To be willing to re-examine objectively the ways in which he uses energy and resources.

To know how to solve a problem through discussion or dialogue.

To know how to carry out a project.

T.O. 4.11 **To investigate** ways in which man can benefit from the use of energy and resources.

Progress, development, improved quality of life, . . .

T.O. 4.12 **To investigate** the risks and dangers involved in excessive exploitation of resources and energy.

Over-consumption, waste, . . .

5° Environmental Influences on Living Organisms

GENERAL OBJECTIVE: TO KNOW THE REASONS FOR THE SURVIVAL AND PROLIFERATION OF AN ORGANISM.

Skill: To develop different abilities (resourcefulness).

Attitude: To be aware of the dimension of harmony in the environment (understanding of nature).

Skill		Learning Content
	**Attitude:** To be aware of the details of environmental phenomena.	
To know how to record specific data in the form of drawings, notes, . . .	T.O. 5.1 **To explain** how the structure of a given animal enables it to carry out its activities.	Organization of time: reproduction, feeding, use of space, movement, . . .
To know how to analyze patterns of movement.	5.1.1 **To describe** the action that comes to mind on observing the incisors of a given gnawing animal.	Tearing.
To know how to interpret an observed fact.	5.1.2 **To describe** the action that comes to mind on observing the webbed feet of a duck or frog.	Swimming.
	5.1.3 **To describe** the position of a frog's limbs while swimming.	
	5.1.4 **To describe** the position of a fish's body while swimming.	
	5.1.5 **To describe** the action that comes to mind on observing the powerful hind legs of a hare.	Jumping.
	5.1.6 **To describe** the position of a hare's limbs when it jumps.	Extended. . . .
	5.1.7 **To describe** the action that comes to mind on observing the thumb of a hand.	Gripping e.g. squirrel, raccoon, monkey, man, . . .
	5.1.8 **To describe** the position of the thumb when it grips.	Thumb is at 90° angle to the fingers.

5.1.9	**To describe** the action that comes to mind on observing the hooves of a quadruped.	Running, galloping, . . .
5.1.10	**To describe** the position of the hooves in relation to the ground when running.	
5.1.11	**To describe** the position of a given bird's wings when flying.	Stretched out, . . .
5.1.12	**To explain** the importance of a fur coat to an animal.	Resists cold or heat, . . .
5.1.13	**To describe** the action that comes to mind on observing a cat's claws.	Climbing.
T.O. 5.2	**To explain** how the particular structure of a plant or a tree enables it to carry out its activities.	
5.2.1	**To explain** the importance of the horizontal position of the branches of a fir tree.	Facilitates the absorption of light.
5.2.2	**To explain** the importance of the high position of the leaves of a maple tree.	Facilitates the absorption of light.
5.2.3	**To explain** the importance of the particular structure of a dandelion seed.	Light glider: easily dispersed by the wind.
5.2.4	**To explain** the importance of the particular structure of a maple seed.	Heavy glider: not easily dispersed by the wind.
5.2.5	**To explain** the importance of the dull appearance of a maple leaf.	Reduces loss of light by reflection.
5.2.6	**To explain** the importance of the large surface area of a maple leaf.	Good light absorption, . . .
5.2.7	**To explain** the importance of the large number of needles on a fir tree.	Good light reception, . . .
5.2.8	**To explain** the importance of the small surface area of the needle of a fir tree.	Resistance to cold, . . .
5.2.9	**To explain** the importance of the bud scales of a tree.	Protection against cold, . . .
5.2.10	**To explain** the importance of the underground bulb of a given plant (e.g. trillium, tulip).	Resistance to cold, storage of energy reserve, . . .
5.2.11	**To explain** the importance of resin (gum) in the bark of a fir tree.	Resistance to cold, helps prevent withering. . .

Attitude: To be willing to take an investigative approach.

To know how to interpret the results of an experiment.

To know how to recognize whether or not an assumption is confirmed by the results.

T.O. 5.3 **To differentiate** between "basic requirements" and "optimum requirements."

Optimum requirements are related to the level of tolerance to light, temperature, and atmospheric humidity, . . .

5.3.1 **To discover**, by means of an experiment, the response of a plant to variations in light intensity.

5.3.2 **To discover**, by means of an experiment, the response of a plant to variations in temperature.

5.3.3 **To discover**, by means of an experiment, the response of a plant to variations in the amount of water it receives.

5.3.4 **To identify** conditions which, if changed, would modify the optimal development of an organism.

Attitude: To be willing to take an investigative approach.

To know how to relate a series of observations made over a period of time.

T.O. 5.4 **To identify** the following stages on a diagram of the life cycle of a flowering plant: plant in full leaf, flower, fruit, seed.

5.4.1 **To discover**, by means of an experiment, the changes that occur in the different parts of a flower.

T.O. 5.5 **To identify** the following stages on a diagram of the life cycle of an insect: egg, larva, nymph or pupa, adult.

5.5.1 **To discover**, by means of an experiment, the transformation of an insect from larva to adult (metamorphosis).

Attitude: To be willing to follow a structured approach in consulting reference material.

To know how to find an explanation of a phenomenon on his own.

To know how to verify the truth of his arguments with the aid of reference materials (books, films, . . .).

T.O. 5.6	**To identify** one or more reasons for a particular activity of a given organism.	E.g. the trillium grows before the leaves of a forest appear. Why?
5.6.1	**To investigate** the reasons for a given construction: beaver lodge, ant nest, beehive, spider web, . . .	Need for shelter, need for food, support for moving from one place to another, means of protection, . . .
5.6.2	**To investigate** the reasons for the song of a given bird, or the cry of a given animal.	Establishing of territory, identification of individuals, attraction of females, means of defence, use in display, (mating gestures), . . .
5.6.3	**To investigate** the reasons for the visible markings on a given animal, e.g. speculum of a duck, white tail of a deer, red mark on a seagull's beak.	Identification of the species, use in display, indication of intent, use as alarm signal, . . .
5.6.4	**To investigate** the reasons for the scent trails and scent markings of a given animal.	Establishing of territory, identification of living space, identification of the species, use as alarm signal, attraction of a mate, . . .
5.6.5	**To investigate** the reasons for the actions of a prey faced with a predator.	Hiding from the predator, fleeing from the predator, confronting the predator, . . .
5.6.6	**To investigate** the reasons for the actions of a predator in pursuing his prey.	Moves constantly, conserves its energy during the hunt, attacks weak animals, . . .
5.6.7	**To investigate** the reasons for the metamorphosis of a given insect.	Mechanism for protection from the elements, taking up a new habitat, . . .
5.6.8	**To investigate** the reasons for the falling of the leaves of a tree in autumn.	Mechanism for protection from the elements, energy conservation, decrease in exposed surface area, . . .
5.6.9	**To investigate** the reasons for the persistence of the needles of fir trees.	Mechanism for protection against the elements, energy conservation, early activity, . . .

5.6.10	**To investigate** the reasons for the flowering of particular given plants in the undergrowth.	Exposure to sun before the leaves form on the trees, . . .
5.6.11	**To investigate** the reasons for the presence of small leaves on the upper part of a tree and large leaves on the lower part.	Adaptation to light, . . .
T.O. 5.7	**To identify** the advantages of researching new varieties and strains in agriculture.	Economic importance: — increased profits for the producer, — lower prices for the consumer.
5.7.1	**To give** a simple definition of the word "variety."	Subdivision of a species, limited to variation of certain individual characteristics.
5.7.2	**To identify** techniques employed by researchers to obtain a variety or strain.	Selection of parents, selection of offspring, reproduction.
5.7.3	**To name** qualities sought in individual specimens in working to obtain a variety or new strain.	Resistance to cold, resistance to disease, resistance to parasites.

Attitude: To be willing to re-examine objectively the ways in which he relates to nature.

To know how to solve a problem through discussion or dialogue.

To know how to carry out a project.

T.O. 5.8	**To investigate** the ways in which man can benefit from his relationships with nature.	Improvement of man's living environment to meet his needs, adaptation of man to environmental conditions, appropriate recreational activities, . . .
T.O. 5.9	**To investigate** the risks and dangers involved in the ways that man relates to nature.	Alienation, acceptance of ugliness and noise.

APPENDIX E

EXCERPTS FROM QUEBEC HUMAN BIOLOGY CURRICULUM

(1984)

4. Content and Objectives of the Course

4.1 FUNCTION OF NUTRITION

General Objective of the Module:

To develop the types of personal commitment necessary for the maintenance of health, based on the study of the various aspects of nutrition and their interdependence.

4.1.1 UNIT 1: Intake: Food and Air

Terminal Objective of the Unit:

To analyze the composition of a menu, based on the qualitative and quantitative needs of typical adolescents, and to describe the role of oxygen in nutrition.

4.1.1.1 Role of Food

The pupil should be able:

Terminal Objective:

To associate the most commonly consumed foods with their roles in the body.

provided that beforehand he is able:

Intermediate Objectives	Related Content
1. **To name** the 3 main roles of food.	(a) For building and repairing: proteins, water (meat, fish, cheese, nuts).
2. **To associate** common foods with each role.	(b) As sources of energy: carbohydrates, (sugar, starchy foods), fats (butter), proteins.
	(c) As regulators: vitamins, water, mineral salts, cellulose (fruits, vegetables, etc.).

4.1.1.2 Food Requirements

The pupil should be able:

Terminal Objective:

To determine the quantity and quality of food needed by adolescents based on the given information.

provided that beforehand he is able:

Intermediate Objectives	Related Content
1. **To evaluate** the quantitative needs of adolescents.	(a) in water (b) in building foods (c) in energy foods (d) in regulating foods

2. **To develop** a daily menu which meets the energy requirements of adolescents.	1g of proteins = 16 kJ 1g of fats = 36 kJ 1g of carbohydrates = 16 kJ Approximately 12 800 kJ

4.1.1.3 Air and Its Components

The pupil should be able:

Terminal Objective:

To describe the role of oxygen in nutrition.

provided that beforehand he is able:

Intermediate Objectives	Related Content
1. **To name** the three main components of air and their proportions.	Nitrogen (79%), oxygen (21%), carbon dioxide (Traces).
2. **To determine**, experimentally, the percentage of oxygen in the air.	21%
3. **To determine**, experimentally, the role of oxygen in combustion.	Oxygen supports combustion.
4. **To show** that the oxygen which entered the body supports combustion.	Glucose + oxygen ⟶ energy (heat) + carbon dioxide + water.

4.1.2 UNIT II: Transformation and Selection of Intake

Terminal Objective of the Unit:

To identify the changes which occur in air and foods before certain of their components enter the blood.

4.1.2.1 Anatomy of the Digestive System

The pupil should be able:

Terminal Objective:

To locate the main parts of the human digestive system on a diagram.

provided that beforehand he is able:

Intermediate Objectives	Related Content
1. **To name** and **locate** five parts of the digestive tract.	Mouth, esophagus, stomach, small intestine, large intestine.
2. **To name** and **locate** five digestive glands.	Salivary glands, gastric glands, liver, pancreas, intestinal glands.
3. **To indicate** the difference between the digestive tract and the digestive glands.	**Digestive tract:** site of digestion, transport, storage and absorption.

	Glands: secrete enzymes necessary for chemical digestion, and are found either within the digestive tract or attached to it.

4.1.2.2 Physiology of Digestion

The pupil should be able:

Terminal Objective

To associate the main stages of digestion with the breakdown of complex foods.

provided that beforehand he is able:

Intermediate Objectives	Related Content
1. **To describe** the mechanical phases of digestion.	**Mouth:** Chewing and swallowing **Stomach:** mixing and storing. **Intestine:** mixing and peristalsis.
2. **To differentiate** experimentally a mechanical change from a chemical change.	**Mechanical:** foods are broken down into relatively large particles by physical means. The food still retains its original chemical composition. **Chemical:** foods are further broken down into simpler chemical components.
3. **To illustrate** the general role of digestion, using diagrams.	Decomposition of complex food molecules into simpler food molecules (Ex: proteins → amino acids).
4. **To define** the process of absorption and **locate** where it occurs.	Absorption of simple food molecules into the blood through the small intestine.
5. **To indicate** what happens to undigested foods.	Passage into the large intestine for storage and elimination.

4.1.2.3 Hygiene of the Digestive System

The pupil should be able:

Terminal Objective

To list some principles of hygiene relative to the digestive system and apply them to the maintenance of his health.

provided that beforehand he is able:

Intermediate Objectives	Related Content
1. **To indicate** three measures that are considered part of preventive dental hygiene.	(a) Diet rich in calcium and phosphorous. (b) Regular brushing of the teeth. (c) Regular visits to the dentist.

2. **To name** the principal dental care policy.	April 1983 — Refer to the pamphlet "WE CARE" — Oral Surgery Program, Dental Services Program and Dental Prostheses. (Régie de l'Ass.-maladie du Qué.)
3. **To identify** two preventive measures related to the hygiene of the large intestine.	(a) Diet rich in cellulose. (b) Physical exercise.

4.1.2.4 Anatomy of the Respiratory System

The pupil should be able:

Terminal Objective

To locate the main structures of the human respiratory system on a diagram.

provided that beforehand he is able:

Intermediate Objectives	Related Content
1. **To name** and **locate** 5 parts of the respiratory system.	Nasal cavities, pharynx, trachea, bronchi, lungs.
2. **To compare** the area of the alveoli with a surface of similar magnitude.	200 m^2 of alveolar surface.

4.1.2.5 Physiology of the Respiratory System

The pupil should be able:

Terminal Objective:

To associate the entry of air into the lungs with its absorption into the blood.

provided that beforehand he is able:

Intermediate Objectives	Related Content
1. **To describe** the mechanism for the inspiration and expiration of air.	Role of the ribs and of the diaphragm.
2. **To illustrate** by means of a diagram, the passage of oxygen from the alveoli to the blood vessels.	Diffusion. Permeability of the membranes.

4.1.2.6 Hygiene of the Respiratory System

The pupil should be able:

Terminal Objective:

To identify those factors which contribute to the proper functioning of the respiratory system.

provided that beforehand, he is able:

Intermediate Objectives	Related Content
1. **To describe** the filtration system found and its limitations with respect to pollutants.	Filtration and heating: hair in the nostrils, mucus in the respiratory tract, cilia of the trachea and of the bronchial tubes.
2. **Name** some effects of a current pollutant: tobacco.	(a) Lung cancer (b) Chronic bronchitis (c) Emphysema (d) Cardiovascular diseases (e) Decrease in life expectancy
3. **To suggest** two ways of improving the air quality.	(a) Development of green spaces (b) Reduction of atmospheric pollutants.

4.1.3 UNIT III: Transportation of Selected Intakes

Terminal Objective of the Unit:

To specify the nature and the importance of the circulatory system.

4.1.3.1 Anatomy of the Circulatory System

The pupil should be able:

Terminal Objective:

To describe the main organs of the circulatory system, and their function in blood circulation.

provided that beforehand, he is able:

Intermediate Objectives	Related Content
1. **To name** the main components of the blood.	**Liquid:** the plasma. **Elements involved:** red and white corpuscules, blood platelets.
2. **To verify**, with the aid of a microscope, the existence of two of the three types of cells present in the blood.	Red corpuscules and white corpuscules (the blood platelets are difficult to observe).
3. **To give** the function of each type of cell.	**Red corpuscules:** transportation **White corpuscules:** defence **Platelets:** coagulation.
4. **To name** the main components of plasma.	Water and nutrients (glucose, amino-acids, salts).
5. **To give** the functions of plasma.	(a) gives fluidity to the blood (b) transports nutrients (c) contains antibodies
6. **To give** the origin of lymph.	Liquid: derived from the blood that left the blood vessels at the level of the capillaries.
7. **To name** the main components of lymph.	Plasma and white corpuscules.

8. **To describe** the functions of lymph.	(a) Transports nutrients at the cellular level. (b) Collects cell waste.
9. **To identify** the cavities of a mammalian heart, using a diagram.	Two atria Two ventricles
10. **To identify** the vessels connected to the heart, using a diagram.	Venae cavae, aorta, pulmonary veins, pulmonary arteries.
11. **To identify** the pathways of blood circulation using a diagram.	Pulmonary circulation and systemic circulation.
12. **To describe** the circulation of the blood through the capillaries.	Slow and regular flow of the red corpuscules, in single file, through the vessels.

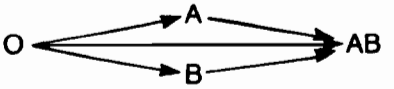
4.1.3.2 Physiology of the Circulatory System

The pupil should be able:

Terminal Objective:

To establish a relationship between the circulatory system and some aspects of human physiology that affect his life.

provided that beforehand, he is able:

Intermediate Objectives	Related Content
1. **To make** a chart comparing vaccine, antibody, and immunity, which illustrates their relationships.	**Vaccine:** dead or weakened antigens which stimulate the production of antibodies. **Antibodies:** part of the defence system of the body, they help neutralize antigens for various lengths of time.
2. **To describe** the importance of vaccination.	(a) **for oneself:** protection against certain diseases. (b) **for others:** prevention of epidemics.
3. **To give** two well-known examples of vaccinations.	Tuberculosis, polio, smallpox, measles, diphtheria.
4. **To determine** his own blood type, experimentally.	Group A B AB or O 44% 8% 3% 45%
5. **To define** blood transfusion.	Transfer of the blood of an individual called a donor to another individual called a recipient.
6. **To solve** exercises involving transfusions and incompatible blood types.	 (Rh^+ or Rh^-)
7. **To list** the factors that show the importance of capillary circulation.	(a) Links arteries and veins. (b) Very closely knit network. (c) Site of exchange between blood and cells. (d) Site of diapedesis.
8. **To list** the main materials exchanged between the capillaries and the cells.	(a) water (b) nutrients (c) oxygen (d) waste

4.1.3.3 Cardiovascular Hygiene

The pupil should be able:

Terminal Objective

To be aware of certain cardiovascular problems and to suggest means of preventing them.

provided that beforehand he is able:

Intermediate Objectives	Related Content
1. **To list** the bad effects of lack of exercise, obesity and use of tobacco on the heart-beat rate.	**Lack of exercise:** reduces the strength of the heart and the elasticity of the arteries; interferes with the flow of the blood. **Obesity:** atheroma (deposit of cholesterol on the internal walls of the arteries), coronary embolism. **Use of tobacco:** exacerbates the dangers of poor nutrition.
2. **To list** rules for a healthy heart.	(a) Regular physical exercise of gradually increasing intensity. (b) Sound nutrition. (c) Elimination of the use of tobacco.
3. **To define** blood pressure.	Pressure of the blood within the arteries which is due to the contraction of the heart and of the elasticity of the arteries.
4. **To measure** his blood pressure.	(a) systolic pressure. (b) diastolic pressure.
5. **To compare** his blood pressure to the normal range of blood pressure.	
6. **To name** two dangers of hypertension (high blood pressure).	(a) Danger of rupture of the arteries followed by hemorrhage. (b) Danger of fatigue of the cardiac muscle.
7. **To give** two symptoms of hypotension (low blood pressure).	Dizziness, lack of energy.

4.1.4 UNIT IV: Metabolism of the Intake

Terminal Objective of the Unit:

To specify the nature and the importance of cell activities.

4.1.4.1 Cellular Structures

The pupil should be able:

Terminal Objective:

To describe cells and their relationship to the structures of a living organism.

provided that beforehand he is able:

Intermediate Objectives	Related Content
1. **To observe** some cells through a microscope.	(a) Use of the microscope. (b) Human cells (mucous membrane). Plant cells (onion). Dead cells (cork).
2. **To describe** the relative size of a cell.	Usually invisible to the naked eye. Smaller than a pin head but larger than a molecule.
3. **To make** an evaluation of the approximate number of cells in the human body.	Volume of the body divided by the volume of a typical cell.
4. **To observe** and identify three basic cell structures.	(a) Cell membrane. (b) Cytoplasm. (c) Nucleus.
5. **To indicate** the main role of each of these structures.	Cell Membrane: exchange. Cytoplasm: transportation. Nucleus: control.
6. **To list** the materials exchanged between the cell and its environment and name the processes involved.	Nutrients, waste, water, oxygen, osmosis, diffusion, pinocytosis.
7. **To show** the universality of the cell in living organisms.	Examination of several types of cells: protozoan, animal, plant.

4.1.4.2 Cell Activities

The pupil should be able:

Terminal Objective:

To describe the importance of cellular respiration and specify its different stages.

provided that beforehand he is able:

Intermediate Objectives	Related Content
1. **To define** cellular respiration.	In the presence of oxygen the food transforms into energy, and eliminates carbon dioxide and urea.
2. **To indicate** the role of oxygen in cellular respiration.	Oxygen is essential to the process of breaking down food in order to release energy from the food molecules (combustion).
3. **To compare** the energy supplied by fats, carbohydrates, and proteins.	Fats: 36 kJ/gram. Carbohydrates: 16 kJ/gram. Proteins: 16 kJ/gram.
4. **To name** the principal waste product of the: (a) combustion of fats and carbohydrates; (b) metabolism of proteins.	(a) Carbon dioxide (b) Urea

5. **To show** the importance of the elimination of waste.	Toxicity of these substances. Detoxification of the organism.

4.1.5 UNIT V: Utilization of Intake

Terminal Objective of the Unit:

To describe how the body makes use of these raw materials.

4.1.5.1 Growth and Repair

The pupil should be able:

Terminal Objective:

To illustrate the relationship between the growth and repair of the body and the intake of food and air.

provided that beforehand he is able:

Intermediate Objectives	Related Content
1. **To identify** the main stages of human growth.	(a) Rapid during early childhood. (b) Upsurge at the beginning of adolescence, followed by stabilization. (c) Non-existent in adulthood.
2. **To show** that growth is the result of cell division.	The proliferation of cells increases the volume and the mass of the body.
3. **To name** three factors which promote growth.	(a) Intra-cellular controls (chromosomes or heredity). (b) Action of certain glands (pituitary and thyroid). (c) Quality of nutrition.
4. **To list** situations that require body repair.	(a) Normal wear: blood, skin, bones, mucous membrane. (b) Accidents: hemorrhage, fracture, cut, burn, sprain, dislocation.
5. **To find**, with the help of a first aid manual, the treatment for four types of accidental injuries which would: (a) encourage natural repair processes, (b) avoid infection.	Setting, immobilization, disinfection, bandaging, tourniquet, pressure bandage, antibiotics, etc.

4.1.5.2 Utilization of Carbohydrates and Fats

The pupil should be able:

Terminal Objective

To establish the relationship between his food energy intake and his energy expenditure.

provided that beforehand he is able:

Intermediate Objectives	Related Content
1. **To make** a chart comparing the energy needed for: (a) maintaining body temperature (b) work	Relative inactivity or office work: 9 660 to 10 500 kJ Sedentary manual work: 10 500 to 12 600 kJ Work of moderate intensity: 12 600 kJ to 16 800 kJ Hard labour: 16 800 to 21 000 kJ
2. **To measure** body temperature using a thermometer.	Production of heat energy when at rest. Normal temperature: 37° C.
3. **To calculate** the energy expenditure of an adolescent during different types of activity.	Walking (3,5 km) on a horizontal plane. 604 kJ Walking (2,2 km) with a load of 5 kg, on a horizontal plane. 1 196 kJ Ascending 30 m on a 30° slope. 607 kJ Bicycling 4,5 km on flat ground 1 318 kJ 6,5 km 2 400 kJ 6,5 km with adverse wind 2 520 kJ Playing hockey 4 200 kJ
4. **To calculate** the energy value of the foods consumed by an adolescent in one day.	Reminder: Energy value: (a) Carbohydrates: 16 kJ/gram (b) Proteins: 16 kJ/gram (c) Fats: 36 kJ/gram

4.1.5.3 Balance Between Food Intake and Activities

The pupil should be able:

Terminal Objective

To recognize the importance of a balanced life style.

provided that beforehand he is able:

Intermediate Objectives	Related Content
1. **To evaluate** his diet and activities from the viewpoint of energy intake and expenditure.	Balance: Health Surplus: overweight Lack: growth problems
2. **To make an inventory** of the resources in his immediate environment which favour: (a) a balanced diet, (b) physical activities.	In: (a) the school; (b) the family; (c) the municipality; (d) Communications: radio, T.V., newspapers.

3. **To list** the advantages of choosing a balanced life style.	(a) Physical fitness (b) Better organ function (c) Proper functioning of the excretory organs (d) Food economy (e) Growth consistency.

4.1.6 UNIT VI: Elimination of Waste

Terminal Objective of the Unit:

To describe the roles of the lungs and the kidneys in maintaining the constant composition of the blood.

4.1.6.1 Elimination of Carbon Dioxide

The pupil should be able:

Terminal Objective:

To recognize the lungs as the most important organs for the elimination of carbon dioxide.

provided that beforehand he is able:

Intermediate Objectives	Related Content
1. Using an indicator, **to detect** the presence of carbon dioxide in: (a) air which is to be inhaled. (b) the vicinity of intense combustion. (c) air which has been exhaled.	Internal or external combustion produces carbon dioxide as a waste product.
2. **To compare**, using given information, the composition of inhaled and exhaled air.	Inhaled air: N_2, 79%, O_2, 21%, CO_2 traces. Exhaled air: N_2, 79%, O_2, 16%, CO_2, 4,5%.
3. **To trace**, on a chart, the path followed by carbon dioxide gas throughout the body.	Cell (production) ⟶ blood (transportation) ⟶ lungs (expulsion).
4. **To measure** respiratory rhythm. (a) at rest, (b) after physical exercise.	The difference indicates an increased supply of oxygen is needed for combustion, and that an increased elimination of carbon dioxide waste occurs.
5. **To establish** the relationship between cellular respiration, the level of carbon dioxide in the blood, and respiratory rhythm.	The more food the cell consumes to produce energy, the more carbon dioxide waste it produces. The latter increases in the blood and is expelled by the lungs at a rhythm proportional to its level in the blood.
6. **To name** three means of diminishing a tendency to shortness of breath.	(a) Regular exercise. (b) Elimination of excess weight. (c) Elimination of smoking.
7. **To state** two contributions of the lungs to the maintaining of constant blood composition.	(a) Oxygen enrichment. (b) Elimination of carbon dioxide.

4.1.6.2 Role of the Kidneys in the Elimination of Nitrogenous Wastes.

The pupil should be able:

Terminal Objective

To describe the renal excretory system, and to **associate** it with the elimination of nitrogenous wastes.

provided that beforehand he is able:

Intermediate Objectives	Related Content
1. **To name** four parts of the renal excretory system.	(a) Kidneys (b) Ureters (c) Bladder (d) Urethra
2. **To describe** the function of each of these parts.	(a) Kidneys: filter the blood and eliminate waste. (b) Ureters: conduct urine from the kidneys to the bladder. (c) Bladder: stores urine (d) Urethra: conducts urine from the bladder to the exterior of the body.
3. **To trace** on a diagram the path followed by nitrogenous waste.	(a) Released by the cells (b) Carried by the blood (c) Eliminated by the renal excretory system.
4. **To list** the factors that cause variations in the quantity of urine.	(a) Quantity of water absorbed (b) Quality of nutrition: mineral salts in particular (c) Quantity of water eliminated through perspiration.
5. **To name** three contributions of the kidneys towards the blood equilibrium.	(a) Regulate the quantity of water (b) Regulate the quantity of mineral salts (c) Remove nitrogenous wastes

4.2 FUNCTION OF THE RELATIONSHIPS

General Objective of the Module:

To recognize that the sense organs, the nervous system, and the locomotor system are different means of communicating with the environment.

4.2.1 UNIT I: Sensory Relationships

Terminal Objective of the Unit:

To show the similarity in function among the sense organs, and the importance of preventive hygiene for the proper functioning of the nervous system.

4.2.1.1 Environment: Source of Stimuli

The pupil should be able:

Terminal Objective:

To identify external sources of stimuli and associate them with receptor organs.

provided that beforehand he is able:

Intermediate Objectives	Related Content
1. **To make** a list of the types of stimuli that can be provided.	(a) light and color: eye (b) sound: ear (c) odour: nose (d) flavour: tongue (e) hot and cold: tongue, skin (f) pressure on the skin (g) pain: generalized
2. **To associate** each of the stimuli with a receptor organ.	

4.2.1.2 Anatomy of the Eye

The pupil should be able:

Terminal Objective:

To describe the anatomical structures of the eye.

provided that beforehand he is able:

Intermediate Objectives	Related Content
1. **To draw and label** a diagram of a cross section of the eye.	Membrane: sclerotic choroid retina Transparent areas: vitreous humour aqueous humour crystalline lens

2. **To list** the differences between the transparent areas and the membranes of the eye.	Transparent areas: clear in the center of the eye... Membranes: on the periphery, opaque (except for the cornea)
3. **To list** the roles: (a) of each of the membranes (b) of all the transparent areas.	Sclerotic: rigid, gives the eye its shape. Choroid: provides nourishment to the eye. Retina: active nervous membrane. Transparent areas: system of lenses and of the conduction of light waves.

4.2.1.3 Physiology of the Eye

The pupil should be able:

Terminal Objective:

To describe the passage of light, its transformation into nerve impulses in the eye, and the transmission of these impulses to the cerebrum.

provided that beforehand he is able:

Intermediate Objectives	Related Content
1. **To trace**, the path followed by light rays to the receptor, the retina, using a diagram of the eye.	Function of the crystalline lens and the transparent humors.
2. **To state** the characteristics of the nerve cells that compose the retina.	(a) specialized (b) excitable (c) capable of generating and conducting a nerve impulse.
3. **To describe** the structure of the optic nerve.	Nerve tissue formed by the axons of retinal cells.
4. **To describe** the role of the optic nerve in the transmission of nerve impulses.	Transmits nerve impulses from the retina to the brain.
5. **To locate** the cerebrum on a diagram of the brain.	Excluding the other components of the brain.
6. **To locate**, on a diagram of the cerebrum, the optic area, the center of vision.	In relation to the other areas of the cerebrum.

4.2.1.4 Hygiene of the Eye

The pupil should be able:

Terminal Objective

To realize the importance both of good vision and of the correction of any visual abnormalities.

provided that beforehand he is able:

Intermediate Objectives	Related Content
1. **To measure** his own visual acuity, with the help of a chart.	Understanding the terms 10/20, 20/20, 8/20 etc.
2. **To give** the causes and the effects of: (a) myopia, (b) hyperopia.	Myopia: the image is focused in front of the retina therefore distant objects are blurred. Hyperopia: the image is focused behind the retina, therefore close objects are blurred.
3. **To distinguish** between hyperopia and presbyopia.	(a) Effects are identical (b) Causes are different Hyperopia: flattened eyeball Presbyopia: age, faculty of adaptation diminished.
4. **To describe** the corrections effected by the use of eyeglasses or of contact lenses.	Myopia: concave lenses Hyperopia and presbyopia: convex lenses.
5. **To name** some rules for reducing eye strain.	(a) Sufficient light (b) Suitable distance for reading: 20 to 30 centimeters (c) Allow the eye to rest by occasionally changing the focal distance being used.

4.2.1.5 Anatomy and Physiology of the Ear

The pupil should be able:

Terminal Objective

To describe the passage of sound waves, their transformation into nerve impulses in the ear, and the transmission of these impulses to the cerebrum.

provided that beforehand he is able:

Intermediate Objectives	Related Content
1. **To locate**, on a diagram the external ear, the middle ear, and the inner ear.	**External** (external to the cranium): pinna, and auditory canal. **Middle** (small cavity in the temporal bone): eardrum, ossicles, Eustachian tube. **Inner** (cavity in the petrous portion of the temporal bone): labyrinth and cochlea.
2. **To list** in order the structures involved in the transmission of sound.	Pinna → auditory canal → eardrum → ossicles → cochlea → auditory nerve → auditory area of the brain.
3. **To identify** and **locate** the receptor, the transmitter, and the interpreter involved in hearing.	**Receptor:** ear **Transmitter:** auditory nerve **Interpreter:** auditory area of the brain.

4.2.1.6 Hygiene of the Ear

The pupil should be able:

Terminal Objective
To explain the main causes of diminished hearing acuity, and give ways of avoiding them.

providing that beforehand he is able:

Intermediate Objectives	Related Content
1. **To name** three possible causes of diminished hearing acuity.	(a) Partial or complete obstruction of the auditory canal by wax. (b) Rupture of the eardrum. (c) Loss of sensitivity of mechanical structures (eardrum, ossicles).
2. **To relate** rules of hygiene to the above mentioned causes.	(a) Have wax removed. (b) Avoid high-pitched and piercing sounds, and undersea diving with blocked Eustachian tubes. (c) Avoid loud and prolonged sounds: industries, discotheques, etc.

4.2.1.7 Anatomy and Physiology of the Skin

The pupil should be able:

Terminal Objective
To describe the skin as a receptor organ for stimuli.

provided that beforehand he is able:

Intermediate Objectives	Related Content
1. **To locate** on a diagram of a cross section three main layers of the skin.	(a) Epidermis (b) Dermis (c) Subcutaneous layer
2. **To name** the main sensations perceived by the receptors in the skin.	(a) Tactile sensations (b) Painful sensations (c) Thermal sensations
3. **To associate** different skin structures with each of these sensations.	i.e. Corpuscles and free nerve endings.
4. **To show** experimentally that the distribution of sensitive points is uneven.	**Tactile acuity** about 500 000 points of touch, separated by 2 to 70 mm according to location. **Thermal:** 20 000 hot spots 250 000 cold spots. It is the difference in temperature that is perceived. **Pain:** about 170 spots per cm^2, especially the free nerve endings.

5. **To name** each of the structures which has the role of receptor, transmitter, or interpreter of touch.	(a) Skin (free nerve endings and corpuscles) (b) Sensory nerves, spinal cord (c) Cerebrum
6. **To name** three non-sensory roles of the skin.	(a) Protection (b) Excretion (c) Manufacture of Vitamin D

4.2.1.8 Hygiene of the Skin

The pupil should be able:

Terminal Objective

To explain the importance of skin hygiene and describe how it can be maintained.

provided that beforehand he is able:

Intermediate Objectives	Related Content
1. **To name** three advantages of having a clean skin.	(a) Improved functioning of the skin. (b) Personal well-being (c) Well-being of others
2. **To name** two ways of avoiding sunburn.	(a) Gradually increasing the time of exposure (b) Protection by appropriate sunscreening and blocking preparations.
3. **To make** a list of some rules of hygiene relating to acne.	(a) Washing 3 times a day (b) Keeping hands away from the face (c) Avoiding ill-treatment of the skin (d) Avoiding the use of skin treatment and cleansing preparations rich in oil. (e) Practicing good nutrition

4.2.1.9 Taste and Smell

The pupil should be able:

Terminal Objective

To describe the organs of taste and smell, and **explain** their functional relationship.

provided that beforehand, he is able:

Intermediate Objectives	Related Content
1. **To locate** and indicate the functioning of: (a) the olfactory receptors,	(a) **Olfactory receptors:** superior part of the nasal cavities. Stimulated by odoriferous gaseous substances.
(b) the taste buds.	(b) **Taste buds:** on the tongue. Stimulated by substances in solution.
2. **To enumerate** the conditions necessary for perception: (a) of odours,	(a) **Odour:** gaseous, chemical, odoriferous molecules. Air carries the molecules to the olfactory receptors.

(b) of flavours.	(b) **Flavour:** soluble chemical molecules having a flavour coming into contact with the tastebuds.
3. **To describe** the relationship which exists between taste and smell.	A blocked nose diminishes the sense of taste. Mint has no taste, but produces a sensation of flavor due to its strong odour.
4. **To name** each of the structures which has the role of receptor, transmitter, or interpreter.	**Smell:** Receptor: nose (olfactory receptor cells) Transmitter: olfactory nerve Interpreter: olfactory area of the cerebrum. **Taste:** Receptor: tongue (taste buds) Transmitter: nerve fibres originating from taste buds Interpreter: gustatory area of the cerebrum.
5. **To state** two rules of hygiene which may help to preserve these two senses.	**Smell:** maintenance of open air passages and proper humidity of the mucous membranes. **Taste:** strong flavours (pepper, spices, salt), alcohol, and tobacco lessen the sensitivity of taste.

4.2.1.10 Nervous System

The pupil should be able:

Terminal Objective

To understand and be able **to explain** various aspects of the functioning of the central nervous system.

provided that beforehand he is able:

Intermediate Objectives	Related Content
1. **To recognize** the main parts of the central nervous system.	Brain: (a) cerebrum (b) brain stem (c) cerebellum
2. **To identify** the structures that transmit impulses.	Spinal cord Nerves
3. **To list** two functions of the brain.	(a) Detection and processing of information coming from outside the body (sensitivity) and from inside the body (equilibrium, coordination). (b) Control of voluntary movements.
4. **To indicate** the role played by the central nervous system in: (a) thought processes (b) reflexes	(a) **Thought processes:** located throughout the cerebrum. Note importance of the prefrontal area. (b) **Reflexes:** occur at the level of the spinal cord, (fixed, automatic responses).

5. **To indicate** two means of improving intellectual performance.	(a) Stimulating environment. (b) Balanced life-style (nutrition, exercise, rest).
6. **To list** the reasons why damage caused to nerve cells either by accident or through drug abuse is permanent.	(a) The nerve cell does not regenerate itself. (b) The transmission of impulses may diminish or stop. (c) The interpretation of the impulse may be distorted, interrupted, or only partially completed.

4.2.2 UNIT II: Locomotor System

Terminal Objective of the Unit:

To show that the structural organization of the muscles and of the bones permits locomotor movement.

4.2.2.1 General Structure

The pupil should be able:

Terminal Objective

To outline the advantages of the various structures of the human body.

provided that beforehand he is able:

Intermediate Objectives	Related Content
1. **To locate** the three anatomical regions of the body.	(a) Head (b) Trunk (c) Limbs
2. **To state** some advantages of being able to stand upright.	(a) Head in an elevated position. (b) Forelimbs free for uses other than locomotion.

4.2.2.2 Skeleton

The pupil should be able:

Terminal Objective:

To describe the function of the skeleton in supporting the soft organs and movements of the body.

provided that beforehand he is able:

Intermediate Objectives	Related Content
1. **To identify** the two component parts of the head.	(a) Cranium (b) Face
2. **To describe** the shape of the cranial bones, their arrangement, and the way they are joined together.	Flat bones, dome-shaped, and joined together in such a way that in adulthood they are immovable.

3. **To give** the function of the cranium.	Protection of the brain.
4. **To describe** the composition of the thorax and the arrangement of the ribs.	(a) Thoracic vertebrae, ribs and sternum (b) The ribs form a dome supported by the sternum and have limited up and down mobility.
5. **To describe** the role of the ribs in the exchange of gases.	Change volume of the thorax.
6. **To make** a diagram of the vertebral column showing the curvature, the number of vertebrae, and the way they are linked.	Double curvature 33 vertebrae (32 to 34) Articular cartilage allowing limited movement.
7. **To relate** the structures of the vertebral column to its mobility and resistance.	Flexibility (double curvature), mobility (a great many elements), resistance to shocks (double curvature and discs of cartilage).
8. **To describe** using a model, the alignment of the first two vertebrae.	Inclination and rotation around an axis.
9. **To connect** the types of joints found in the limbs of the body with the kinds of movement they allow.	Rotation and extension.
10. **To compare** the skeletal structure of an upper limb with that of a lower limb.	Each has a girdle 3 main articulations Carpals and tarsals Fingers and toes
11. **To describe** the role of the ligaments in a joint.	Join the bones together and allow freedom of movement.
12. **To identify** the marrow, the growth cartilage, and the periosteum of a fresh, young bone.	Red marrow, yellow marrow, growth cartilage between the epiphyses and the diaphysis.
13. **To enumerate** the functions of the marrow, of the growth cartilage, and of the periosteum.	**Periosteum:** thin, external covering of the bone. **Red marrow:** formation of the red corpuscules **Periosteum:** growth in width **Growth Cartilage:** growth in length
14. **To list** the differences between a **fracture**, a **sprain**, and a **dislocation**.	**Fracture:** broken bone, shortened limb, internal cracking sound. **Sprain:** abnormal displacement of an articulation, with immediate resetting, often accompanied by tearing of the ligaments. **Dislocation:** Displacement of the articulatory surfaces, with straining and/or tearing of the ligaments. No cracking sound.
15. **To explain** with the help of a first aid manual, how to treat these three injuries.	**Fracture:** setting, immobilization. **Dislocation:** resetting, immobilization. **Sprain:** immobilization.
16. **To list** the conditions necessary for the normal development of the skeleton.	(a) Diet rich in calcium and phosphorous. (b) Adequate supply of vitamins A and D. (c) Normal functioning of the following endocrine glands: thyroid, pituitary, thymus.

4.2.2.3 Muscles

The pupil should be able:

Terminal Objective:

To associate the structure and the functioning of the muscles with movement.

provided that beforehand he is able:

Intermediate Objectives	Related Content
1. **To locate**, experimentally, the muscles responsible for: (a) flexion of the forearm (b) abduction of the arm.	(a) Biceps brachii (b) Deltoid
2. **Name** the visible changes that occur when muscles contract.	(a) They become shorter (b) They increase in volume
3. **To identify** the different parts of a muscle.	(a) Tendon (b) Belly (c) Aponeurosis
4. **To show**, with the help of a diagram or a model, that muscular contraction produces movement.	Contraction produces movement of the bones which in turn leads to movement of the other structures. Active factor of movement.
5. **The show** that the attachment of the muscle to the bone is essential.	If there is no attachment the muscle works in a vacuum without making the bone move.
6. **To show** the antagonistic effect of the biceps and of the triceps, using a diagram or model.	Flexor and extensor.
7. **To list** and describe the stimuli which cause muscles to react.	Stimuli: — Nature: (a) Electricity — Physical (b) Physical shocks — Physical (c) Acids, bases, and salts — Chemical (d) Nerve impulses — Physiological
8. **To trace**, on a diagram, the path followed by a nerve impulse during a voluntary act.	Cerebrum ⟶ spinal cord ⟶ motor nerve ⟶ muscle
9. **To define** muscular elasticity.	Property of a muscle which enables it to return to its initial length after contraction.
10. **To name** two causes of muscular fatigue.	(a) Insufficient supply of energy and oxygen. (b) Accumulation of waste.
11. **To name** 4 ways of increasing resistance to muscular fatigue.	(a) Regular graduated exercises. (b) Relaxation (c) Good nutrition (d) Adequate ventilation

4.3 FUNCTION OF REPRODUCTION

General Objective of the Module:

To develop informed attitudes regarding his or her sexuality, based on knowledge of the structure and function of the reproductive system.

4.3.1 UNIT I: Anatomy and Physiology of the Reproductive System

Terminal Objective of the Unit

To explain the anatomy and physiology of the male and female reproductive systems.

4.3.1.1 Anatomy of the Female Reproductive System

The pupil should be able:

Terminal Objective

To identify those parts of the female anatomy which belong to the reproductive system.

provided that beforehand, he is able:

Intermediate Objectives	Related Content
1. **To identify**, using a diagram. of the female reproductive system, its main component parts.	**Vulva:** external genital orifice, mid-pelvic region. **Vagina:** copulatory organ, internal, posterior to the bladder and urethra.
2. **To locate**, on a cut-away or a diagram of the female anatomy, the main structures of the reproductive system.	**Uterus:** embryonic development, inside the pelvic cavity.
3. **To state** the roles of the main structures of the female reproductive system.	**Fallopian Tubes:** Collect and transport the ovum, originate from opposite sides of the uterus. **Ovaries:** Structures located at the ends of the Fallopian Tubes (that produce ova).

4.3.1.2 The Adolescent and Puberty

The pupil should be able:

Terminal Objective

To understand the role of hormones in the onset of puberty, and **to view** this as a physiological stage in the development of the adolescent.

provided that beforehand, he is able:

Intermediate Objectives	Related Content
1. **To identify**, using a diagram, the glands belonging to the female reproductive system.	Endocrine glands: (a) pituitary gland (b) ovaries
2. **To define** hormones.	Chemical substances secreted into the blood in small quantities by the endocrine glands, and transported through the body to target organs.
3. **To name** the pituitary hormones.	FSH and LH (Follicle Stimulating Hormone and Luteinizing Hormone).
4. **To name** the ovarian hormones.	Estrogen and progesterone
5. **To define** puberty.	All the physiological and psychological changes that occur when a young person passes from childhood to adolescence.
6. **To describe** the role of the sex hormones in the onset of puberty.	Effects on the whole body; and in particular, on the beginning of the menstrual cycle.
7. **To list** the changes that appear in the adolescent girl at the time of puberty.	(a) Development of the breasts (b) Development of pubic and axillary hair. (c) Development of the figure in general. (d) Physical transformation of the genitals, and beginning of the menstrual cycle.

4.3.1.3 Menstrual Cycle

The pupil should be able:

Terminal Objective:

To identify the phases of a 28 day menstrual cycle, and show the importance of hormones to this cycle.

provided that beforehand he or she is able:

Intermediate Objectives	Related Content
1. **To name** the changes that occur during the menstrual cycle.	(a) Development of the uterine mucosa (b) Ovulation (c) Desquamation of the uterine mucosa: menstruation
2. **To describe** the action of ovarian hormones within the cycle.	(a) Phase 1: increased level of estrogen which leads to the start of ovulation. (b) Phase 2: increased level of progesterone which causes the mucosa to thicken. (c) Decreased level of estrogen and of progesterone induce menstruation.
3. **To specify** the time of ovulation.	At the time when the level of estrogen is at its highest.

4. **To give** two clues by which the time of ovulation can be identified.	(a) Slight rise in temperature. (b) Mild pain in the abdomen.
5. **To describe** the significance of ovulation.	(a) Ultimate reason for the menstrual cycle (b) Renders the woman fertile
6. **To give** the main characteristics of the ovum.	Ovum: (a) Chromosome Number (b) Size (c) Survival

4.3.1.4 Feminine Hygiene

The pupil should be able:

Terminal Objective:

To give the general rules of feminine hygiene during and between menstrual periods.

provided that beforehand, he or she is able:

Intermediate Objectives	Related Content
1. **To identify**, using a diagram, the external female genitalia.	Vulva: (a) Labia majora (b) Labia minora (c) Clitoris (d) Bartholin's Gland (e) Hymen
2. **To indicate** the role of Bartholin's Glands.	Secretion of a lubricating substance.
3. **To establish** a few rules of personal hygiene pertaining to the female genitalia.	Removal of secretions: Cleanliness of the external organs; Daily washing.
4. **To recognize** the possibility of pain at the time of menstruation.	Mild sensation of depression, headaches and backaches, mild cramps and abdominal heaviness.
5. **To specify** the role of physical exercise at the time of menstruation.	Relieves tension, alleviates symptoms.
6. **To state** the importance of the cleanliness of the skin at the time of menstruation.	(a) Health (b) Personal well-being (c) Well-being of others (Taking a bath, a shower or swimming are not harmful.)

4.3.1.5 Anatomy of the Male Reproductive System

The pupil should be able:

Terminal Objective:

To identify those parts of the male anatomy that belong to the reproductive system.

provided that beforehand, he or she is able:

Intermediate Objectives	Related Content
1. **To identify**, using a diagram of the male reproductive system, its main component parts.	**Penis:** External copulatory organ. Vas deferens: Collect and transport sperm.
2. **To locate**, on a cut-away or diagram of the male anatomy, the main structures of the reproductive system.	**Prostate gland:** produces accessory secretions, located around the urethra beneath the bladder.
3. **To state** the roles of the main structures of the male reproductive system.	**Seminal vesicles:** produce accessory secretions, located on each vas deferens near the prostate. **Cowper's Gland:** produces accessory secretions, located on the pathway of the vas deferens. **Testes:** produce sperm, external structures enclosed by the scrotum.

4.3.1.6 Puberty and the Adolescent

The pupil should be able:

Terminal Objective:

To understand the role of hormones in the onset of puberty, and **to view** this as a physiological stage in the development of the adolescent.

provided that beforehand, he is able:

Intermediate Objectives	Related Content
1. **To identify**, using a diagram, the glands belonging to the male reproductive system.	Endocrine glands: Pituitary Testes
2. **To name** the sex hormones secreted by the testes.	Androgens and testosterone
3. **To differentiate** between the action of the pituitary hormones in men and women.	Continuous action of the pituitary hormones in men, cyclic in women.
4. **To list** the changes that occur in an adolescent boy at the time of puberty.	(a) Change in the voice (b) Growth of pubic and axillary hair (c) Development of the figure in general (d) Physical transformation of the genitals and the beginning of the production of sperm cells.

4.3.1.7 Physiology of the Male Reproductive System

The pupil should be able:

Terminal Objective:

To describe the structure of the sperm and the process of ejaculation.

provided that beforehand he is able:

Intermediate Objectives	Related Content
1. **To describe** the main characteristics of sperm cells.	Sperm cells: (a) Number (b) Chromosome number (c) Size (d) Survival
2. **To describe** the components of the semen.	Sperm and secretions of the seminal vesicles, prostate, Cowper's glands.
3. **To trace**, on a diagram, the paths followed by semen and by urine.	Semen: testes, vas defenrens Urethra sperm Urine: bladder, urethra (presence of sphincters)
4. **To describe** the nature and importance of erection.	Accumulation of blood in the sinuses of the erectile tissue under the influence of the nervous system. Allows the organ to achieve sufficient firmness to ensure sexual relations.
5. **To distinguish** between erection and ejaculation.	Erection is not always accompanied by ejaculation, which is the spasmodic ejection of the semen.

4.3.1.8 Male Hygiene

The pupil should be able:

Terminal Objective:

To state the general rules of hygiene of the male genitalia.

provided that beforehand, he is able:

Intermediate Objectives	Related Content
1. **To define** circumcision.	Removal of the prepuce
2. **To specify** cases that necessitate circumcision.	(a) narrow prepuce (b) Hygiene (c) Religious rite
3. **To define** smegma	Sebaceous secretion that collects at the base of the glans.
4. **To establish** a few rules of personal hygiene relative to the male genitalia.	Removal of smegma. Cleanliness of the scrotum and penis. Daily washing.
5. **To state** the advantages of cleanliness of the genitalia.	(a) Health (b) Personal well-being (c) Well-being of others

4.3.2 UNIT II: Physiology of Procreation

Terminal Objective of the Unit:

To acquire a knowledge of the physiology of procreation that will encourage intelligent sexual behavior.

4.3.2.1 Sexual Relations

The pupil should be able:

Terminal Objective

To establish a difference between the biological function of reproduction of the species and the function of sexual relations between two human beings.

provided that beforehand, he is able:

Intermediate Objectives	Related Content
1. **To define** sexual intercourse.	Technically, coitus is the introduction of the penis into the vagina, usually preceded by foreplay.
2. **To define** sexual relations.	Intimate bond uniting two persons in sexual intercourse for the purpose of procreation and/or the mutual expression of love.
3. **To state** the conditions necessary to human sexual relations.	(a) Mutual love (b) Full mutual acceptance (c) Physical and psychological security (d) Sense of responsibility

4.3.2.2 Fertilization: possible physiological consequence of sexual intercourse.

The pupil should be able:

Terminal Objective:

To recognize fertilization as a possible physiological consequence of sexual intercourse.

provided that beforehand, he is able:

Intermediate Objectives	Related Content
1. **To identify** the place and the time at which the sperm and the ovum meet.	1/3 of the way down the Fallopian tubes, usually between the 12th and 24th hour after ovulation.
2. **To define** fertilization.	Union of the male and female gametes resulting in the formation of a zygote, and ultimately of a child.
3. **To identify** the rights and the needs of a child at birth.	(a) Life (b) Love (c) Security (d) Responsible parental care (e) Family environment

4.3.2.3 Pregnancy, Normal Consequence of Fertilization

The pupil should be able:

Terminal Objective:

To establish the relationship between the development of the embryo and the progress of the pregnancy.

provided that beforehand, he or she is able:

Intermediate Objectives	Related Content
1. **To distinguish** between the zygote, the embryo, and the fetus.	Different terms illustrating the uterine development of the child in the time and in size.
2. **To explain** growth as a function of the division and specialization of cells.	Mitosis as a means of cellular growth. Specialization: increasing interdependence and efficiency.
3. **To recognize** cessation of menstruation as one of the first signs of pregnancy.	Persistence of corpus luteum. Implantation of the egg.
4. **To describe** the basis of the pregnancy test.	Surplus of hormones present in the mother's urine. These hormones, when injected, cause changes in the genitalia of female laboratory animals.
5. **To indicate** the role of the following structures: (a) Placenta (b) Umbilical cord (c) Amniotic fluid	**Placenta:** membrane uniting the embryo to the mother. Ensures exchanges between the two. **Umbilical cord:** structure joining the embryo to the placenta. Cut at birth, the scar forms the navel. **Amniotic fluid:** liquid surrounding the embryo.
6. **To compare** fraternal twins and identical twins, on a basis of their origin and their resemblance.	Fraternal twins: two ova, two sperms, little resemblance. Identical twins: one ovum and one sperm only, a great deal of resemblance.
7. **To indicate** precautions to be taken during pregnancy.	Proper nutrition. Adequate physical exercise. Avoidance of tobacco, alcohol, self-medication, and drug abuse. Sufficient sleep. Healthy environment.

4.3.2.4 Birth

The pupil should be able:

Terminal Objective:

To describe the process of birth and the first moments of the baby's life.

provided that beforehand, he is able:

Intermediate Objectives	Related Content
1. **To state** two early signs of labor.	(a) Uterine contractions (b) Blood-streaked discharge of loss of amniotic fluid.
2. **To distinguish** between natural birth, cesarean section, and induced labor.	(a) **Natural birth:** with the active participation of the mother, no anaesthetic (b) **Cesarean section:** under anaesthetic by opening the abdominal cavity and the uterus. (c) **Induced labor:** stimulated by the injection of a hormone.
3. **To name** four stages of labor.	(a) Dilation of the cervix (b) Entrance of the fetus into the vagina. (c) Birth of the baby. (d) Expulsion of the placenta
4. **To list** the rules of hygiene applicable to a new-born baby.	(a) Clean the nostrils and mouth (b) Cut, tie and disinfect the umbilical cord. (c) Facilitate the first breaths: slaps on the behind or on the soles of the feet. (d) Lukewarm water bath (e) Heat, dim light, quiet (f) Breast feeding if possible
5. **To identify** the sources of regional aid offered to future parents and to parents during the pre- and post-natal periods.	Varies according to the region: inquire.

4.3.2.5 Possible Pathological Consequences of Sexual Intercourse

The pupil should be able:

Terminal Objective:

To specify the knowledge and behaviours required in relation to sexually transmitted diseases.

provided that beforehand, he or she is able:

Intermediate Objectives	Related Content
1. **To name** two of the most widespread sexually transmitted diseases.	(a) Gonorrhea (b) Syphilis
2. **To identify** the main symptoms of a sexually transmitted disease.	(a) Gonorrhea: (1) Woman: Vaginal discharge of a greenish color. Irritation of the vulva. (80% asymptomatic). (2) Man: Painful micturition Discharge of pus through the urethra. (20% asymptomatic).

	(b) Syphilis: Chancre Skin outbreak Heart attack Blindness Insanity Death
3. **Identify** means of preventing S.T.D.	(a) Abstention from sexual intercourse. (b) Condoms (c) Germicidal vaginal foam (d) Washing of the genitalia with a bactericidal soap
4. In the case of contracting S.T.D. **list** the reasons for early consultation of a doctor.	(a) Accurate diagnosis (b) Serious consequences of the diseases (c) Very contagious (d) Easier to cure (e) Simpler treatment
5. **To give** the reasons why the partner should be informed in cases of S.T.D.	(a) Fairness (b) Social responsibility (c) Highly contagious diseases (d) Prevention of an epidemic

4.3.2.6 Prevention of Fertilization

The pupil should be able:

Terminal Objective:

To list the principal methods of birth control, and **to describe** his or her responsibilities regarding these methods.

provided that beforehand, he or she is able:

Intermediate Objectives	Related Content
1. **To list** some methods of birth control.	(a) Chemical: pills, spermicide (b) Mechanical: I.U.D. (intrauterine device) diaphragm, condom (c) Surgical: tubal ligation vasectomy (d) Ogino-Knauss Basal body temperature Bellings and abstention
2. **To describe** how birth control methods work.	
3. **To be aware** of effectiveness of birth control methods.	
4. **To be aware** of the side effects of birth control methods.	
5. **To discuss** the responsibility of the two partners in the choice of a method of birth control.	(a) Harmlessness (b) Effectiveness (c) Moral convictions (d) Religious convictions

6. **To identify** the sources of information and services for young persons under 18 years of age.	Variable according to region: inquire.

APPENDIX F

EXCERPTS FROM QUEBEC HUMAN BIOLOGY CURRICULUM GUIDE

(1987)

4.1.3.1 ANATOMY OF THE CIRCULATORY SYSTEM

TERMINAL OBJECTIVE

To describe the main components of the circulatory system and their relationship to blood circulation.

1. DEFINITION OF THE OBJECTIVE

In this objective, the main parts of the circulatory system are examined. The description of these parts should be limited to basic characteristics: the valves through which blood enters and leaves the heart, the elasticity of the arteries, the valves of the veins, the thinness of the capillaries, and so forth. Teachers should keep in mind that if one or more functions of a component are not pertinent to the course, then information about them should be considered complementary.

Teachers should focus on helping students learn the content for the intermediate objectives.

2. LEARNING CONTENT

Knowledge:	The structure of the heart and the blood vessels. The composition of the blood and the function of its components.
Skills:	Relating blood circulation to the distribution of nutrients and O_2 throughout the organism, and to the transport of CO_2. Using a microscope.

3. GENERAL APPROACH

According to where student interest lies, the teacher can begin with either a description of blood or a description of the components of the circulatory system.

Teachers should help students to achieve this objective with its twelve intermediate objectives by following a logical order. Students are usually very interested in the circulatory system and its parts. For this reason teachers should avoid digressions, particularly in the area of pathology. Students should be informed that the normal functions of the components will be studied first, and that they should record their questions and keep them until the end of the class. In this way, teachers will be able to

present a logical whole to the class without interruption; lab sessions will give students the opportunity to ask questions on specific areas of the learning content. Keeping questions until the end of the lesson serves a double purpose: first, students can better understand the answer; and second, the answers themselves constitute a review of the content covered.

4. LEARNING ACTIVITIES

Instead of providing students with long descriptions of anatomical data, it is much more formative to have students do the work themselves. Teachers should not ask students to memorize descriptions, but instead, should favour creative methods such as making drawings, diagrams, collages, and cutting and pasting.

The third intermediate objective involves using a microscope. Once students are familiar with its use, it can be highly motivating. The opposite unfortunately is also true: if students experience difficulties in focusing and using the microscope, they may become frustrated.

There are several brands of microscopes on the market, with variable focusing mechanisms. It is strongly recommended that teachers be completely familiar with the model that their students will be using. Regardless of the model selected, there are certain directives regarding the use of microscopes that should be followed:

1. The microscope must be carried in both hands.
2. It is important to use the microscope in a well-lit area.
3. The object under study must be centred on the slide.
4. The smallest lens must always be focused first.
5. The microscope must be focused by lowering the stage or raising the body tube, i.e., by drawing away from the object under observation.
6. Before putting the microscope away, the smallest objective must be in place, and the microscope must be covered by its protective casing.

The teacher can avoid many of the problems that arise in using microscopes by posting a large sign listing the rules for the type of microscope to be used in class. Students could be introduced to microscope use by learning to focus on simple objects such as chalkdust, hair, and so forth. They could follow this up with a blood smear. It is recommended to use a simple staining agent such as methylene blue to make the white corpuscles stand out. It would be too ambitious at this point to look for blood platelets because the type of microscope that is generally used in the classroom is not sophisticated enough for this purpose.

Observing capillary circulation requires the use of living animals such as frogs and goldfish. Handling live animals is a very delicate matter and teachers must insist that all living creatures be treated with respect, including those in the laboratory[1]. Teachers are advised to demonstrate the experiment before the students do their own investigations.

Goldfish are usually wrapped in moist cotton and placed in a petri dish with the tail over the edge. The tail is examined under low magnification between glass slides. If the cotton is kept wet a goldfish can survive under these conditions for twenty minutes without difficulty.

Frogs are placed on their backs on a thin wooden board into which a hole has been bored; their legs are attached to the board with string or adhesive tape. The interstitial webbing of one hind foot is placed above the hole and examined under low magnification.

In both cases students are asked to look for a vessel showing red corpuscles circulating in single file. This formation is unique to the capillaries.

5. EVALUATION

It is preferable to evaluate the lab activity using an observation checklist. It is important to remember that this objective requires a descriptive knowledge of phenomena. The use of directives such as "draw arrows to indicate the flow of blood into the heart" is recommended.

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1 Canadian Council of Animal Care, **Guide to the Care and Use of Experimental Animals**, 2 vols., Ottawa, Ont.: CCAC, 1980-1984

4.1.3.2 PHYSIOLOGY OF THE CIRCULATORY SYSTEM

TERMINAL OBJECTIVE

To identify the relationship between certain anatomical structures in the circulatory system and physiological phenomena which affect the body.

1. DEFINITION OF THE OBJECTIVE

This objective covers three types of phenomena: vaccination, blood groups and capillary circulation.

On the subject of vaccination it is important for students to familiarize themselves with the following relationship:

antigen ⟶ antibody ⟶ immunity

It is preferable to limit explanations to pathogenic agents. Defining such concepts as anaphylactic shock is not necessary. The fourth intermediate objective suggests that students determine their own blood types experimentally. However, the difficulty of ensuring sanitary conditions in the classroom makes it undesirable to do this activity. The risk of spreading infections is too high.

With regard to capillary circulation, it is most important to help students understand that exchanges take place within this circulation. The concepts of phagocytosis and diapedesis will be considered at a later stage.

2. LEARNING CONTENT

Knowledge:	The definitions of antigen, antibodies, and immunization. Substances exchanged in the capillaries.
Skills:	Differentiating between antigen, antibodies and immunity. Resolving the problems of incompatible blood types and blood transfusions. Identifying the relationship between capillaries and exchanges.

3. GENERAL APPROACH

Vaccination should be regarded as a matter of individual and public health. Certain religious groups are against vaccination; these views must be respected out of consideration for students in the class who may belong to those groups. However, students should be made aware of the social implications of vaccination. There is a great deal of research presently being done on vaccination, with new vaccines being discovered. It is therefore in the teacher's interest to keep abreast of vaccines currently in use as well as those that are being introduced on the market.

The exchanges which occur in the capillaries can be studied with reference to the exchange of gases in the lungs. An interesting way to introduce the intermediate objectives relating to capillary exchange would be to review the concept of lung exchanges and draw a parallel between it and the capillary network.

4. LEARNING ACTIVITIES

An effective method of making students aware of the utility of vaccinations is to have them do a study on the major epidemics which have decimated humanity throughout history; alternatively they could do a limited survey of poliomyelitis cases in their own environment. Few families emerged unscathed when this virus disease was at its peak.

The experiments on osmosis and diffusion would be interesting to review in relation to exchanges in the capillary network. This would be a propitious moment to divide students into groups (ideally four to a group) and to have the students work with thistle tubes, pressing the opening against different materials such as leather, a pork bladder, waxed paper, plastic wrap, rubber. This exercise enables students to familiarize themselves with the concept of the permeability of membranes, which will be studied in greater detail in the study of the cell.

5. EVALUATION

This objective primarily involves identifying the relationships between different elements. Teachers should focus on drawing up criteria to evaluate students' skill in establishing these links.

4.1.3.3 HEALTH AND THE CARDIOVASCULATOR SYSTEM

TERMINAL OBJECTIVE

To recognize certain cardiovascular problems and to suggest ways of preventing them.

1. DEFINITION OF THE OBJECTIVE

The purpose here is to give students an overview rather than a detailed study of cardiovascular problems. Teachers can show the importance of cardiovascular health by listing heart diseases that students have already heard of: strokes, atheroscelerosis and heart attacks. However, it is unnecessary to go into detail regarding particular heart defects.

2. LEARNING CONTENT

Knowledge:	The main threats to a healthy heart and blood vessels.
	The definition of high blood pressure.
Skills:	Doing exercises to improve cardiovascular health.
	Taking one's blood pressure.
	Taking one's pulse.

3. GENERAL APPROACH

Cardiovascular disease is the number one cause of death and illness in Québec today. Once students have digested this fact, teachers should discuss possible means of preventing heart disease. The human being should be presented as a harmonious entity. It is counterproductive to harp on the problems and possible mechanical breakdowns that can occur in the cardiovascular machine as this can undermine students' faith in their own body's capacities.

Teachers could adopt a gentle approach in explaining how the cardiovascular system operates. Rather than unthinkingly stating "To avoid heart attacks, you have to..." teachers could say "The heart and its vessels need the same type of care that you give other parts of your body."

This is a good time to remind students about the relationships between the different systems, particularly those already studied.

4. LEARNING ACTIVITIES

Students could be given a chance to listen to their heartbeat through a stethoscope if they have not yet done so. They could do also do some activities which would allow them to confirm that physical exercise makes their hearts beat faster.

Another suggestion is to have them take their blood pressure when their hearts are beating at different speeds. This will enable them to establish the relationship between heart rate and blood pressure, and to compare the wide variations found among individuals. Or, students could take their pulses at various points of the body: wrist, neck, temple, ankle, behind the knee, and so forth. At the same time teachers could explain that these points mark the sites of major arteries. Students could develop this further and try to establish the relationship between the pulse and the heartbeat as heard through the stethoscope.

5. EVALUATION

Evaluation should cover students' knowledge of ways of maintaining good health. Students' knowledge or understanding of heart disease per se should not be evaluated.

4.1.4.2 CELL ACTIVITIES

TERMINAL OBJECTIVE

To describe the importance of cellular respiration and to specify the different stages in the process.

1. DEFINITION OF THE OBJECTIVE

Cellular respiration is a very complex phenomenon. Teachers should simplify the process as much as possible and avoid using chemical formulas. The teacher's goal is to help students understand that, in the presence of oxygen, ingested food is transformed into a certain type of energy in the cell and that this transformation produces certain wastes which must be eliminated.

While a concept such as the **KREBS** cycle is too advanced for Secondary III, teachers can nevertheless emphasize the differences between pulmonary respiration, the exchange of gases, cellular respiration and energy production.

2. LEARNING CONTENT

Knowledge:	Foods and oxygen are transformed into energy by the cell. Different categories of food determine the value of the transformed substance as well as the efficiency of transformation. Energy production results in waste which must be eliminated.
Skills:	Identifying the relationships between nutrition, digestion, respiration, transport and cellular activities. Comparing the energy values of food.

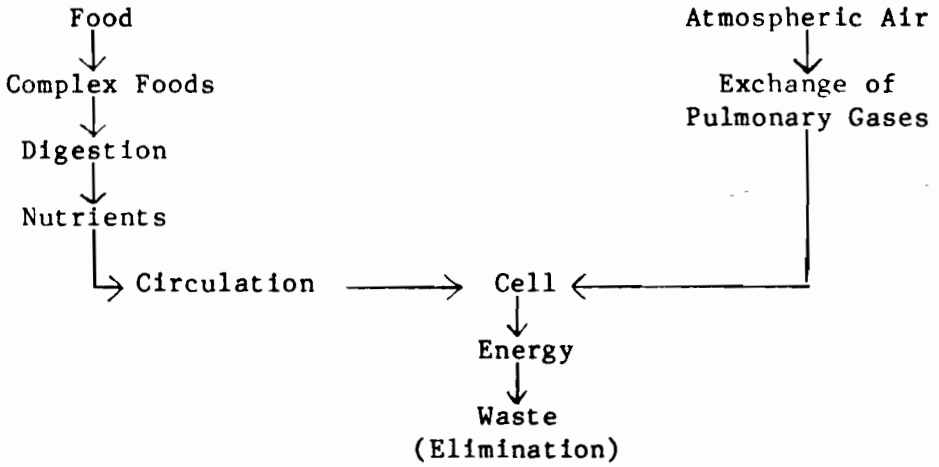
3. GENERAL APPROACH

Cellular respiration should be considered the end goal of all the work carried out by the systems that have already been studied. The sole purpose of digestion, respiration, and transport is to render nutrients and oxygen available to the cell. These substances are transformed in the cell with varying degrees of efficiency depending on the category of food. Like the digestive process, this conversion of substances produces waste products which must be eliminated.

The intermediate objective does not cover the role of the liver in the deamination of amino acids. Should teachers wish to include this topic, it should be as an enrichment activity.

4. LEARNING ACTIVITIES

Teachers can help students grasp the relationship between digestion, respiration, circulation and cellular activities by having them draw a diagram showing these different steps. The following diagram gives a general idea:



Since the intracellular process is relatively complex, the teacher may find that it is easier to explain it by means of analogy. He/she could, for example, ask students to identify similarities and differences between combustion of wood and cellular activities. The teacher could write the students' answers on the board and the students could record them in their notebooks afterwards. Using their own method, the students could then identify those they consider applicable to cellular activity. Answers may vary from one student to another. What is important is that they understand the process.

5. EVALUATION

Evaluation should focus on students' understanding of cellular respiration, rather than their grasp of quantitative data, which varies from one author to the next. Teachers should, however, evaluate students' knowledge of new terms because correct, consistent terminology is essential to effective communication.

4.1.5.2 UTILIZATION OF CARBOHYDRATES AND FATS

TERMINAL OBJECTIVE

To establish the relationship between food energy intake and energy expenditure.

1. DEFINITION OF THE OBJECTIVE

The numerical data provided in the related content section is approximate and intended primarily for the teacher's use.

The figures should be given to students to allow them to calculate their energy expenditure or intake. It is not necessary that they memorize these figures, except for the normal temperature of the human body.

2. LEARNING CONTENT

Knowledge:	The normal temperature of the human body.
Skills:	Taking one's own temperature and reading the thermometer. Doing various calculations. Identifying the relationship between physical exercise and energy expenditure.

3. GENERAL APPROACH

The teacher could begin by giving students the numerical data related to energy expenditure and physical exercise as a basis for discussion. In the course of the discussion, students should come to the realization that the more active they are, the greater their energy consumption and, consequently, the greater their need for energy-producing food and oxygen.

The concrete data given to students constitutes a starting point from which they can form general ideas.

4. LEARNING ACTIVITIES

Body temperature can be taken in several different places, the most accessible being the mouth and the armpit. Teachers can divide students into two groups, and have the members of each group take their temperature in

either of these places and then compare the results. Students will observe that differences in temperatures are minimal.

Students could also be asked to take their temperatures at rest and after physical exercise. The findings could constitute the basis for a discussion in which students are asked to postulate the cause of the increase in temperature. The heart and respiratory rates could also serve for a similar comparison. Other experiments along the same lines could be designed by teachers and students as well.

The menu that students prepared earlier in the program for the different levels of physical activity could also be used here to show the differences between a basic diet and one designed to meet specific energy needs.

5. EVALUATION

Teachers can give students problems to solve if they provide them with the necessary basic data. Memorization is to be avoided at all costs. Evaluation should enable teachers to verify whether students have understood the principle "the more active a person is, the more energy he/she consumes."

4.1.5.3 BALANCE BETWEEN FOOD INTAKE AND PHYSICAL ACTIVITY

TERMINAL OBJECTIVE

To recognize the importance of a balanced lifestyle.

1. DEFINITION OF THE OBJECTIVE

The aim of this objective is very general: to help students develop an awareness of the need for a balanced lifestyle.

2. LEARNING CONTENT

Knowledge:	The advantages of a balanced lifestyle.
Skills:	Evaluating a person's diet.
	Making an inventory of resources.

3. GENERAL APPROACH

The teacher should create learning situations which allow students to recognize the importance of striking a balance between energy intake, food, and energy expenditure.

Earlier in the course, students calculated the caloric and nutritional content of an average diet. They should now be given the opportunity to create personalized menus. As individual needs vary, so do the types and quantity of food required to meet them.

4. LEARNING ACTIVITIES

Students could draw up a list of their main daily activities and use it to evaluate the sample menus prepared earlier on, applying the knowledge they have acquired throughout the course. They could then adapt their menus to fit their personal needs. By comparing their menus, students will see that nutrition is an individual matter.

Students should make an inventory of resources in the community: this could be done as a survey, either in or out of the classroom. More time will be required if it is completed outside.

5. EVALUATION

Evaluation should focus on students' understanding of the concept of balance between intake and energy consumption.

Teachers could also evaluate students' awareness of the advantages of a balanced lifestyle. The purpose of identifying some of the advantages is to motivate students.

4.2.1.2 ANATOMY OF THE EYE
TERMINAL OBJECTIVE

To describe the anatomical structures of the eye.

1. DEFINITION OF THE OBJECTIVE

As in the other anatomical studies, students should work with diagrams. There are six basic components of the eye which students should know and interrelate. They should be able to identify and locate each component on a diagram of the eye and know the role of each structure. The accessory structures of the eye such as the muscles, lacrymal glands, eyelids and so forth need not be covered in great detail.

Teachers should help students to perceive the eye as a receptor of stimuli, and to examine only the structures required to perceive light. Teachers are also reminded that anatomical components are only important insofar as they allow students to understand the physiology or functions of the organs or systems studied.

2. LEARNING CONTENT

Knowledge:	The location and roles of the following structures: sclerotic coat, choroïd, retina, vitreous humour, aqueous humour, crystalline lens.
Skills:	Drawing a diagram of the eye. Labelling the parts on the diagram.

3. GENERAL APPROACH

The study of anatomical structures involves the acquisition of specific knowledge. Interpretation does not come into play. Choroïd, for instance, cannot be more or less present; it is either there, situated in a specific part of the eye, or it is not there. This type of information, which has been reduced to the absolute minimum for the purpose of this course, should be memorized by students.

It is by having students repeat information as often as possible in written and spoken form, rather than by having them read textbooks or listen to definitions, that teachers will help them retain this knowledge. The continual and repeated use of words and concepts over several weeks will

anchor them in students' minds. Teachers should therefore not hesitate to backtrack and review concepts which students have difficulty grasping.

4. LEARNING ACTIVITIES

Drawing, pasting, and colouring are useful tools for helping students memorize structures. Students can draw diagrams and identify their components. They can also try, for example, to identify as many parts of the eye as possible by observing their classmates' eyes, or their own in a mirror. Any other activities which allow students to repeatedly say or write the terms, thereby facilitating memorization, should also be favoured.

5. EVALUATION

Teachers should evaluate whether students are able to describe the structure of the eye and to identify the main parts, and whether they know the functions of these parts.

4.2.1.3 PHYSIOLOGY OF THE EYE

TERMINAL OBJECTIVE

To describe the passage of light, its transformation into nerve impulses in the eye, and the transmission of these impulses to the cerebrum.

1. DEFINITION OF THE OBJECTIVE

The aim of this objective is to have students understand the relationship between receptor, convertor, conductor and analyzer. This relationship exists with all the senses; sight, hearing, smell, taste, and touch. The following information therefore applies to all the senses and will not be repeated under each heading.

In this case the receptor is the anatomical structure known as the eye. Light waves, images and colour are transmitted from one part to another; by the time they reach the retina, certain images are reversed. This is the essential minimum information that students should know. It is not necessary for them to know about the compensatory role of the iris and the cristalline lens in response to brightness, nor the physics involved in light waves. The teacher is free of course to discuss these topics if he/she judges them to be pertinent, but they should not be subject to evaluation.

The transformer in this situation is the retina. The essential idea for students to remember is that the retina is composed of cells and transforms light waves into a form of energy known as a nerve impulse. A concrete example of this phenomena can be seen in the generator of a hydro-electric dam as it transforms water power into electricity. The structure of retinal cells and the different types of nerve cells contained in the retina are not relevant here. The principle of transformation is more important than the process or the phases.

The nerve serves as a conductor. Its function as a conductor or transmittor of nerve impulses is the focus here, rather than its histological structure. Nerves always link two elements; in this instance, the link is between the eye and the brain. The optic nerve carries the nerve impulse between the eye and the brain.

2. LEARNING CONTENT

Knowledge:	Receptor - the eye Transformer - the retina Conductor - the optic nerve Analyzer - the brain
Skills:	On a diagram, tracing the path of light waves in the eye, and the path of the nerve impulse from the eye to the brain.

3. GENERAL APPROACH

Teachers should adopt a comprehensive approach designed to give students a general understanding of the whole perceptual system. Students should not be exposed to a great many physiological or anatomical details, except in very particular circumstances. It is a good idea to begin with an overview of the whole concept before gradually introducing specific details. Teachers should be attuned to students' needs and stop the class if they see that students cannot relate some of the details to the overall process. If the details will not enhance students' understanding of the global phenomenon, teachers should not go into them as they merely hinder the comprehension process.

4. LEARNING ACTIVITIES

Analogies provide a useful means of helping students understand a given phenomenon. The most difficult concept to grasp in this objective is the concept of light waves converting into nerve impulses. Light waves change in nature to become impulses. Such a change can be physically demonstrated by simply connecting a photo-electric cell to a small motor. By comparing the role of the retina to that of the photo-electric cell, the student may find it easier to understand the phenomenon. The combustion engine which converts gas into propulsive energy and the hydro-electric dam which turns water power into electricity are other helpful analogies.

The brain's role as an analyzer may be illustrated using drawings or diagrams of op art. Optical illusions show that the answer given by the brain to the nerve impulses does not always correspond to reality.

4.2.1.5 ANATOMY AND PHYSIOLOGY OF THE EAR

TERMINAL OBJECTIVE

To describe the passage of sound waves, their transformation into nerve impulses in the ear, and the transmission of these impulses to the cerebrum.

1. DEFINITION OF THE OBJECTIVE

The principles outlined for the study of vision also apply to this objective. Anatomy is directly related to physiology. The only anatomical parts which should be considered compulsory learning content are those essential to understanding the hearing process. They can be identified on diagrams.

The hearing process can be broken down into four steps:

RECEPTOR ⟶ TRANSFORMER ⟶ CONDUCTOR and ANALYZER

2. LEARNING CONTENT

Knowledge:	Receptor - external and middle ear Transformer - inner ear Transmitter - auditory nerve Analyzer - brain
Skills:	On a diagram, drawing the path followed by sound waves in the ear and the passage of nerve impulses from the cochlea to the brain.

3. GENERAL APPROACH

It is strongly recommended once more that emphasis be placed on process rather than structure. Once students have understood the process, they will have attained the objective. The purpose in studying the structures is to enhance understanding of the process: if teachers find them useful they can therefore include them in the lesson. They should not, however, use them as an excuse for overloading students with so-called enrichment content.

4. LEARNING ACTIVITIES

The various methods used in the study of vision, such as drawing, colouring, and labelling, are also suitable for this objective. If students have understood that the eye translates light into nerve impulses, they should have no trouble understanding that the ear does the same with sound.

An interesting means of demonstrating the transmission of sound vibrations to the eardrum is to place sand on a tambourine and see how easily it vibrates.

In order to help students understand how sound is transmitted through solids, the teacher can return to the example of the stethoscope which was used in the objective on the heart.

5. EVALUATION

Evaluation should focus on students' knowledge of the parts of the ear and the process by which sound waves are converted into nerve impulses and transmitted to the brain.

4.2.1.10 THE NERVOUS SYSTEM

TERMINAL OBJECTIVE

To understand and be able to explain various aspects of the central nervous system.

1. DEFINITION OF THE OBJECTIVE

This objective should be covered in some detail. It would be unrealistic to expect students to gain a thorough knowledge of the nervous system from this one course, but they can learn the basic facts of this system.

This objective covers several topics. First, the location of the main structures in the system: the brain, the brain stem, the cerebellum, the spinal cord and the nerves. Several of these structures were covered in the section on the senses. The teacher's efforts should be geared towards developing continuity and to helping students grasp the interdependence of these structures. It is out of the question at this point to subdivide the nervous system into its two traditional components. For the purposes of this objective it must be considered as a whole.

Second, the objective deals with the functions of the nervous system; students have already examined those of transmission and interpretation in the study of the sense organs; the voluntary act is still to be covered. The latter originates in the brain, follows basically the same path as the sensory stimuli but in reverse - travelling to the muscles, where it initiates movement. The concept of reflexes may be introduced next. Reflexes are involuntary actions made in response to stimuli which bypass the brain and elicit a response from the spinal cord. In studying intellectual faculties, the teacher should cover only three features: where these faculties are located in the brain, the little known and complex phenomenon of intellect and the brain, and the importance of the prefrontal lobe.

Third, health care with regard to the nervous system is included in this objective. Teachers can cover issues such as alcohol and drugs if it seems appropriate to do so. As needs vary at different times and in different areas, no specific objectives on this topic are included in the course. This means that teachers are free to decide how much time they will devote to these topics.

2. LEARNING CONTENT

Knowledge:	The brain as the centre of neural activity. Everything that originates in and is transmitted to the brain. Reflexes are the exception to the rule and most often serve as a defense mechanism. The brain is a complex and delicate organ whose working can be irreversibly impaired by seemingly minor problems.
Skills:	Drawing a diagram of the main parts of the nervous system. Drawing a diagram of a reflex movement. Drawing a diagram of a voluntary movement. Drawing a diagram of the main centres of activity in the brain.

3. GENERAL APPROACH

It is in the teacher's interest to adopt a systemic approach. The nervous system is first and foremost a pathway of communication. In conjunction with the brain it is the decision-making centre, the coordinator of all physical and intellectual activity that takes place in the body. This is the essential information that students should assimilate in the course. Histological and anatomical details, divisions, and detailed structures are superfluous because these topics will not help students reach a better understanding of neural activity, which is the objective here.

The harmful effects that certain substances have on the nervous system can be pointed out. However, if students are to understand the negative effects of such substances, they must first be able to understand the general workings of the nervous system. For this reason it is more productive to spend ten days studying the normal working of the nervous system and one day studying drug and alcohol abuse, rather than the contrary.

4. LEARNING ACTIVITIES

The drawing and use of diagrams constitutes a simple and worthwhile activity for students.

Teachers could ask students to draw up a list of possible reflex stimuli: the sound of the bell, meal times, and so forth. Such a list will enable the teacher to verify whether students have understood the concept of a reflex and, at the same time, make them aware of the important role that reflexes play in their lives.

If the need is there, teachers could also propose that students do a survey on the use of alcohol and/or drugs. Follow-up could include a panel discussion with or without resource persons.

5. EVALUATION

Evaluation should primarily allow teachers to verify whether students have understood the functions of the nervous system, and whether they have grasped the importance of the nervous system in coordinating all activity in the body.

4.2.2.2 THE SKELETON

TERMINAL OBJECTIVE

To describe the role of the skeleton in supporting the organs and in allowing movement.

1. DEFINITION OF THE OBJECTIVE

This objective covers three topics: the structure of the skeleton, including the joints; growth and development of the skeleton; the composition of bones, and accidents to bones.

Teachers will notice that the intermediate objectives do not use the precise nomenclature for each bone. It is therefore unnecessary for students to memorize the name of every bone. However, if teachers use accurate terminology for the most common bones - the femur, the tibia, the humerus and so forth - during demonstrations and explanations, they will enable students to become familiar with the terms and help increase their vocabulary. These terms should not, however, be subject to evaluation.

Teachers should stress the interrelation between bones and the movements that these bones allow: for example, the particular structure of the cranial cavity, the spine, the hand, or the hip joint. It is the sheer variety and efficiency of these movements that students should grasp rather than the name of each joint or type of movement.

2. LEARNING CONTENT

Knowledge:	The skeleton is composed of a series of rigid, hard components which support the body. The skeleton is solid and flexible at the same time. Bones are passive organs. Bones are composed of mineral salts and food plays an important role in their formation.
Skills:	Creating models to show how joints work.

3. GENERAL APPROACH

There are two paradoxes in this objective which students should know about. The first is that although the skeleton is composed of hard, rigid elements, the entire structure is mobile and flexible. The second paradox

is that while the cranial bones are fused to form a solid dome, the wrist bones move very freely in relation to each other.

It is virtually impossible for teachers to explain these "contradictions" without informing students of the role and structure of the skeleton as a whole. It is necessary for students to know about bones as independent units, but it is more important for them to grasp how bones interrelate. These types of interrelationships are quite diverse. Certain bones offer protection, such as the dome-shaped skull and the thoracic cage. Others, such as the spine, provide support, while still others, like the limbs, constitute a mobile axis, and so forth.

The skeleton can be considered a passive structure in itself. It serves as a support and a frame to which the muscles are attached. In fact the two systems, the bones and the muscles, cannot be separated. They have been considered separately here to facilitate understanding, but the division is artificial. The teacher can present the two systems concurrently if desired.

4. LEARNING ACTIVITIES

A good way of approaching the study of the skeleton is to have students do research and create working models of joints or groups of bones. Construction materials could include heavy cardboard, wood, and elastic bands. An interesting exercise is to have students compare a human skeleton to that of a quadruped.

Students can observe the actual structures of bones — marrow, periosteum, and joint cartilage — by examining a piece of fresh bone and reporting on its physical properties, such as texture, density, and colour. The teacher could demonstrate the chemical structure of bones by demineralizing a portion of the bone in acid, or by burning bones. If appropriate, the teacher could suggest that students try to discover the chemical structure of bone for themselves.

St. John Ambulance has qualified personnel who are often willing to visit schools. Teachers could contact them and ask them to come to the school to speak on bone fractures and breaks.

5. EVALUATION

Evaluation should enable teachers to verify whether students have learned the main role of the skeleton (support, protection for the organs, a frame for muscle attachment) and the composition of a bone.

4.3.2.3 PREGNANCY: THE NORMAL CONSEQUENCE OF FERTILIZATION

TERMINAL OBJECTIVE

To establish the relationship between the development of an embryo and a mother's pregnancy.

1. DEFINITION OF THE OBJECTIVE

It is important for students to grasp the complexity of embryonic development and to appreciate the wonder of it. Teachers do not need to use charts of embryos or to show this development on a day-by-day or month-by-month basis. If desired, teachers could show a good film on the subject. In any case, the details of embryonic development should not be subject to evaluation.

The concept of mitosis is an integral part of this objective, but it should be covered in terms of cellular reproduction, rather than in terms of successive phases.

2. LEARNING CONTENT

Knowledge: The principle behind the pregnancy test.
The role of embryonic structures.

Skills: Distinguishing between zygote, embryo, and fetus.
Identifying the relationship between cell division and embryonic development.

3. GENERAL APPROACH

Once fertilization has taken place, normal physiological development causes the zygote to grow into an embryo and the embryo into a fetus. Teachers should help students to understand that this is a normal phenomenon which is essential for the survival and multiplication of the species.

A woman is a caretaker and is responsible for the development of the embryo. During pregnancy many changes take place in her body. A pregnant woman and her partner are both entrusted with the capacity to give life and are equally responsible for the reproduction of the species.

4. LEARNING ACTIVITIES

Teachers could begin by having students prepare questions about pregnancy; they could then invite a pregnant woman to the class to answer questions or to give a talk.

Students could also do a survey in their school on the number of fraternal and identical twins. If the student population totals at least a thousand, then it is possible to establish valid statistics. Another suggestion is for students to do a survey of twinning in a given family or region.

5. EVALUATION

Although evaluation may focus primarily on the cognitive aspect, it should nevertheless help the teachers to verify whether students have understood the vital role played by women in ensuring the continuation of the species, while keeping in mind that procreation is the role of two responsible partners.

4.3.2.5 POSSIBLE PATHOLOGICAL CONSEQUENCES OF SEXUAL RELATIONS

TERMINAL OBJECTIVE

To specify the knowledge and responsible behaviour required in relation to sexually transmitted diseases.

1. DEFINITION OF THE OBJECTIVE

The course places particular emphasis on certain sexually transmitted diseases: herpes, syphilis, gonorrhea, and AIDS. Teachers could also inform students of others should they wish to.

Teachers should help students to identify the main symptoms of these diseases. It is not necessary for them to know the details of every symptom. What is important is that they have enough knowledge to recognize when such a disease is present. An accurate diagnosis, of course, remains the task of a doctor or nurse.

It is very important to emphasize means of prevention and the need for medical check-ups when symptoms are present. Youngsters in this age-group have probably not heard the expression "shameful diseases," in reference to these diseases, and teachers should make sure that such expressions are not used. Teachers should help students to develop responsible attitudes and to understand the imperative need to inform a partner if an S.T.D. has been contracted.

2. LEARNING CONTENT

Knowledge:	The main sysmptoms of some S.T.D.s. Methods of preventing S.T.D.s. The reasons for having medical check-ups in case of doubt. Reasons for informing one's partner if one has contracted an S.T.D.
Skills:	Consulting a doctor in case of doubt. Informing one's partner if an S.T.D. has been diagnosed.

3. GENERAL APPROACH

A pathological study of S.T.D.s is not the intention here. The goal is to make students aware of their existence, symptoms, and means of transmission. For the most part, sexually transmitted diseases are contracted through sexual contact with persons who have these diseases.

If students have the least doubt as to whether they have contracted one of these diseases they should immediately seek medical advice.

Sexually transmitted diseases are contagious. There is nothing shameful about them. However, because some of them are extremely dangerous, it is imperative that partners be warned. These diseases will not clear up on their own. Furthermore, the fact that a person has had the disease once does not mean that they are immune to it in the future.

4. LEARNING ACTIVITIES

Teachers could invite a qualified person to come into the classroom and answer students' questions. The school nurse and specialists from community health services are usually well prepared, both from a scientific and educational perspective. These persons usually provide interesting information packages for students.

5. EVALUATION

Evaluation should focus on the cognitive aspect. Teachers will verify whether students know the major symptoms of, and methods of preventing, some S.T.D.s, as well as the importance of early diagnosis and the need to inform partners.

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