TEACHING OAC BIOLOGY

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ABSTRACT

This report describes the origin and purpose of the Ministry of education document: Program Outline and Policy as it applies to OAC Biology. It provides analysis of components of the Program Outline and Policy with recommendations for improvement. Evaluation of students and characteristics of graduating students are discussed with recommendations. Difficulties with the OAC Biology guideline are presented with recommendations. A course outline which can be used by students is included.

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1.0 INTRODUCTION

This report is in two parts. Part 1 comments on the goals of education and the specific aims of the science curriculum as outlined in the Ministry of Education document: Program Outline and Policy (Part 1 of the Curriculum Guideline for Science Intermediate and Senior Divisions, 1987). It describes the development of both the Program Outline and Policy and the OAC Biology guideline. It provides analysis of educational goals, curriculum emphasis, components of study units and makes recommendations for improving each of these areas. Next, it reviews some important factors in evaluating students and new information regarding student learning needs. Characteristics which are desirable in graduating students are discussed and recommendations are presented. Finally, difficulties in the OAC Biology guideline are outlined along with recommendations for alleviating these difficulties.

Part 2 outlines the objectives for each unit in the OAC Biology course of study. This is done in a format that can be used by students.

PART I: FACTORS RELATED TO TEACHING OAC BIOLOGY

2.0 ONTARIO MINISTRY OF EDUCATION PROGRAM OUTLINE AND POLICY STATEMENT (ONTARIO SCHOOLS:INTERMEDIATE & SENIOR)

2.1 BACKGROUND

A broadly representative Project team was assembled from across Ontario (see appendix 1) by the Ministry of Education to develop the Program Outline and Policy Statement. In addition, an advisory team was put together. Members of both teams were selected from nominees from different Ontario teachers federations. Selection criteria included experience and a broad understanding of education in Ontario as well as geographic and francophone representation,and male/female balance. These teams met periodically to discuss progress and receive advice.

Teams of practicing teachers headed by a Project team member were assembled to write first drafts of the 15 parts of the Ontario Science Guidelines. The work of the writing teams was subject to extensive and thorough review by the Project team, teachers across the province, and teachers' federations. New, smaller writing teams were then assembled to develop second drafts because they would have no "ownership" in the original draft. They developed the final document which was checked for accuracy, spelling etc.

In summary, the Ministry of Education went to great lengths to involve a wide range of Ontario science teachers in

the development of a Program Outline and Policy Statement and the science guidelines.(1)

2.2 THE GOALS OF EDUCATION

The goals of education are presented by the Ontario Ministry of Education in Part 1 of the OSIS (Ontario Schools,Intermediate and Senior Divisions) Science Guideline-Program Outline and Policy, 1987 (2).

The goals of education consist of helping each student to:

1. develop a responsiveness to the dynamic process of learning
2. develop resourcefulness, adaptability, and creativity in learning and living
3. acquire the basic knowledge and skills needed to comprehend and express ideas through words, numbers, and other symbols
4. develop physical fitness and good health
5. gain satisfaction from participating and from sharing the participation of others in various forms of artistic expression
6. develop a feeling of self-worth
7. develop an understanding of the role of the individual within the family and the role of the family within society

8. acquire skills that contribute to self-reliance in solving practical problems in everyday life
9. develop a sense of personal responsibility in society at the local, national and international levels
10. develop esteem for the cultures, and beliefs of a wide variety of societal groups
11. acquire skills and attitudes that will lead to satisfaction and productivity in the world of work
12. develop respect for the environment and a commitment to the wise use of resources
13. develop values related to personal, ethical, or religious beliefs and to the common welfare of society

2.2.1 Analysis of the Goals of Education

The following are precis of the 13 Goals of Education as quoted from the Science Part 1 Program and Policy document. The precis of each goal is followed by a critical analysis based on the author's opinion.

1. " develop a responsiveness to the dynamic process of learning

Processes of learning include observing, sensing, inquiring, creating, analyzing, synthesizing, evaluating, and communicating. The dynamic aspect of these processes derives from their source in many instinctive human activities, their application to real-life experiences, and their systematic interrelation within the curriculum."

Comment New Ontario Schools:Intermediate Senior (OSIS) science programs place more emphasis on the scientific process and experimentation rather than learning content. There are mandatory activities prescribed in each unit of every science course in the guideline. Because they are mandatory students will be exposed to more of the above processes than in the past. This represents a great improvement over previous courses.

2. " develop resourcefulness, adaptability, and creativity in learning and living

These attributes apply to modes of study and inquiry, to the management of personal affairs such as career plans and leisure activities, and to the ability to deal effectively with challenge and change."

Comment : More than ever, our students will need these skills in order to cope with life in a society which thrives on change. The content base in science subject areas is changing rapidly. Within the science units, different ways of learning such as problem-solving, evaluating, designing experiments, independent research and explaining should have some carry-over application to daily life with emphasis on the skill involved rather than the final product.

3. " acquire the basic knowledge and skills needed to comprehend and express ideas through words, numbers, and other symbols

Such knowledge and skills will assist the learner in applying rational and intuitive processes to the identification and solution of problems by:

a) using language aptly as a means of communication and an instrument of thought;

b) reading, listening, and viewing with comprehension and insight;

c) understanding and using mathematical operations and concepts."

Comment : Students need to be able to communicate their ideas and to understand and use mathematical concepts in science as well as other subjects and in

daily life. Teachers need more emphasis on communication skills in science courses. Teaching these skills should not be viewed as being the role of other subject area teachers.

4. " develop physical fitness and good health

Factors that contribute to fitness and good health include regular physical activity, an understanding of human biology and nutrition, the avoidance of health hazards, and concern for personal well-being."

Comment: An understanding of human physiology and the effect of environmental factors and nutrition on health and well-being of the individual is important. Today's students are less physically active than in the past. They must cope with new health hazards as more information on exposure to substances, such as lead and asbestos, is made public.

5. " gain satisfaction from participating and from sharing the participation of others in various forms of artistic expression

Artistic expression involves the clarification and restructuring of personal perception and experience. It is found in the visual arts, music, drama, and literature, as well as in other areas of the curriculum

where both the expressive and receptive capabilities of the learner are being developed."

Comment: There is ample opportunity in the science program for an appreciation of the aesthetic value of nature. More and more there is an interdisciplinary approach to research and applied science. Teachers should portray the arts as complementary to the sciences and depict the creative aspect of science.

6. " develop a feeling of self-worth

A feeling of self-worth is affected by internal and external influences. Internally it is fostered by realistic self-appraisal, confidence, and conviction in the pursuit of excellence, self-discipline, and the satisfaction of achievement. Externally it is reinforced by encouragement, respect, and supportive evaluation."

Comment Science activities can be chosen to provide an appropriate challenge. Teachers need to find ways to enable students to be successful. Evaluation should be growthful for the individual. How teachers do this will be discussed in more detail in the section on Evaluation (section 3.0).

7. "develop an understanding of the role of the individual within the family and the role of the family within society

Within the family the individual shares responsibility, develops supportive relationships, and acquires values. Within society the family contributes to the stability and quality of a democratic way of life."

Comment: The above view represents the ideal situation and is frequently not the actual situation. In our changing society, students are asked to shoulder more responsibility, sometimes at the expense of family support in single-parent families and families where both parents work outside the home. Values which students acquire in these situations are quite different from those acquired in the ideal situation. It is therefore even more important that educators consider the Societal Implications objectives in the units of study and actively engage students in discussions which will enable them to understand better the effect they have as individuals and as family members in our society.

8. " acquire skills that contribute to self-reliance in solving practical problems in every day life

These skills relate to the skilful management of personal resources, effective participation in legal and civic transactions, the art of parenthood, responsible consumerism, the appropriate use of community agencies and services, the application of accident-prevention techniques, and a practical understanding of the basic technology of home maintenance."

Comment: If teachers bear in mind the practical application of scientific concepts, and if teachers are open to discussion of how these apply to daily life, they will help students achieve this goal. Science should not be done in the isolation of the classroom.

9. "develop a sense of personal responsibility in society at the local, national, and international levels

Awareness of personal responsibility in society grows out of knowledge and understanding of one's community, one's country, and the rest of the world. It is based on an understanding of social order, a respect for the law and the rights of others, and a concern for the quality of life at home and abroad."

Comment Many issues at the fore today are rooted in science eg. resources, pollution, and genetic engineering. Courses should explore the responsibility of individuals and groups such as industry and government in resolving these issues. Teachers should make students aware of the contributions of individual scientists to our knowledge and to our way of life.

10. "develop esteem for the customs, cultures, and beliefs of a wide variety of social groups

This goal is related to social concord and individual enrichment. In Canada it includes regard for:

a) the Native peoples;

b) the English and French founding peoples;

c) multiculturalism;

d) nation identity and unity."

Comment: More realistic terms to replace "esteem" are "understanding and appreciation". Science is international in scope and its benefits as well as negative consequences can and have crossed national boundaries. Witness the results of the achievement of nuclear fission. Many scientific issues are of a global nature and discussion of these is made more balanced by the inclusion of beliefs of various interest groups. For example, when considering an

issue such as logging in the Temagami area, teachers must present the viewpoints of all stakeholders; loggers, native people, environmental groups, outfitters, tourists and the local communities.

11. "acquire skills and attitudes that will lead to satisfaction and productivity in the world of work

In addition to the appropriate academic, technical, and interpersonal skills, this goal relates to good work habits, flexibility, initiative, leadership, the ability to cope with stress, and regard for the dignity of work."

Comment: Good work habits and attitudes are important for productive and satisfying effort. These can be fostered particularly through laboratory activities. Career opportunities can be related to course work where appropriate.

12. "develop respect for the environment and a commitment to the wise use of resources

This goal relates to a knowledgeable concern for the quality of the environment, the careful use of natural resources, and the humane treatment of living things."

Comment: This goal should be emphasized throughout science courses. Teachers should examine their own environmental ethic and be aware that they are role models. Politicians and individuals without much science background particularly in the area of environmental science comprise our governments and industries. These people dismiss or rationalize their activities in the light of short-term gains. Teachers are educating the future opinion-makers and decision-makers of our society. Teachers need to heighten the awareness of their students of the individual and cumulative effect of their activities on our environment and our resources.

13. "develop values related to personal, ethical, or religious beliefs and to the common welfare of society
Moral development in the school depends in part on a consideration of ethical principles and religious beliefs, a respect for the ideals held by others, and the identification of personal and societal values."

Comment: Through discussion of ethical and moral issues, students will consider their own values and be made aware of other viewpoints which may differ from their own. Teachers need to examine the source of values with our students and try to help them

understand the bases for our viewpoints. They must foster a respect for others even though they may disagree with us.

2.2.2 Recommendations concerning goals of education:

In the author's view the goals of education are reasonable and worth pursuing. The author would, however, recommend that:

The Ministry foster teacher commitment to these goals by providing inservice training and professional development because science teachers need to see their potential value for students.

The Ministry develop and make available support materials which explain the goals to students because they are currently written in language for teacher use.

The Ministry make provision for feedback from students and teachers regarding these goals because both teacher and student input is important and relevant.

The Ministry develop a system to measure and report on progress in achieving these goals because feedback is important in all educational development.

2.3 CURRICULUM EMPHASIS

"The goals of education may be realized in part through learning experiences based on the aims of the science curriculum. Such aims are focused on developing in students

* an ability to manage their own lives,
* an acceptable attitude towards the world of work,
* an understanding of the nature of science,
* some degree of scientific literacy." (3)

These aims are based mainly on research done by the U.S. National Science Foundation (N.S.F.) in 1976.(4)(5)

The N.S.F biology study group proposed a model for the teaching of pre-college biology. This model was based on 5 observations:

1) the present character of the scientific enterprise;
2) the current emphasis on scholarship within biological disciplines;
3) biology/social based issues that exist and are likely to persist throughout several decades into the future;
4) personal needs relevant to biology that are evident in contemporary culture;

5) public reactions to conventional educational goals and practices"(5)

The N.S.F. model suggests that biology programs include concepts such as personal needs, social issues and career identification, in addition to the traditional emphasis on knowledge/content.

The term "curriculum emphasis" refers to the combinations of content and curriculum aims, where 'content' is the subject matter (see Tables 1 and 2). For example, a unit on Heat can be taught using the Nature-of-science emphasis. The caloric theory and kinetic-molecular theory can be used to show how theories change. The same unit can be taught using the Environmental-ethic emphasis. Different concepts involving heat can be used in the context of home heating.

There are 11 possible contexts or curriculum emphases (as determined by the Ministry writing team), in which to teach the content of each unit in a course (see Table 2). These have expanded on the 7 curriculum emphases presented by D. A. Roberts in 1982 (6). He explained a curriculum emphasis as a "coherent set of messages" which teachers present to students.

Roberts studied policy statements and science texts published in the last 80 years and from these, synthesized 7 emphases which represent what has been tried in science education

during that time. He does note, however, that these do not represent all that is theoretically possible.

Table 1. The Aims of the Science Curriculum (7)

Students will acquire the following attitudes, skills and knowledge;

1. an understanding of the processes of science
2. skills that are essential for participation in scientific work and technology
3. facility in problem solving through science
4. the basic knowledge needed to function in and contribute to a scientific and technological world
5. respect for the environment and a commitment to the wise use of resources
6. an understanding of the nature of science as a human endeavour
7. an appreciation of technology as the application of scientific knowledge and principles
8. an ability to locate and retrieve scientific information
9. an awareness of the career possibilities in the field of science and technology
10. an awareness of how the knowledge of science enhances personal life management

11. a sensitivity about science and its influence on societal issues and values (for a more detailed explanation of each aim, see Appendix 2)

Table 2 Curriculum Emphases (8)

Aim Plus Content	Equals	Curriculum Emphasis
Aim 1 + Content	=	Nature-of-science emphasis
Aim 2 + Content	=	Skill-development emphasis
Aim 3 + Content	=	Science-and-society emphasis
Aim 4 + Content	=	Knowledge-foundation emphasis
Aim 5 + Content	=	Environmental-ethic emphasis
Aim 6 + Content	=	Human-endeavour emphasis
Aim 7 + Content	=	Science-technology emphasis
Aim 8 + Content	=	Information-processing emphasis
Aim 9 + Content	=	Science-in-employment emphasis
Aim 10 + Content	=	Life-management emphasis
Aim 11 + Content	=	Societal-values emphasis

2.3.1 Analysis of Curriculum Emphasis

This N.S.F. biology study group suggests that Biology has been influenced by several recent developments including new technologies for research, new interdisciplinary perspectives, new concerns about human activities and biology. (9) They recommend that the teaching of biology reflect recent developments.

The organization of the new OSIS science courses is consistent with this N.S.F. recommendation in that it shifts emphasis from the purely academic "structure of the discipline" approach toward a more contemporary, integrated, approach.

In choosing a particular emphasis, teachers must first think about <u>why</u> they are teaching the particular content and develop some kind of theme or paradigm through which to develop topics in each unit. This provides more relevance for the students because it makes it easier to answer the question, "Why are we learning this?" as they pass through a unit.

In addition to providing students with a theme or reason for studying course material, there are other advantages for the curriculum emphases concept(10):

* They enable us to address the goals of education and the aims of science education in a planned way rather than an indirect, " it will happen somehow " manner.

* They provide a useful framework for analyzing textual material with a view to determining its emphasis or bias.

* They allow teachers to see that there is not a single, "correct" way of presenting material.

Roberts (11) differentiates between explicit and implicit messages sent to students. Explicit messages come from the text material and specific resources used while implicit messages are communicated through what is implied and not said. These are more a matter of context. For example, the majority off experiments performed by students are designed by teachers to produce the same result for all students. The implicit message here is that science is a series of truths and experiments must have a "right answer". This does a disservice to the students and paints an incorrect picture of the acquisition of scientific knowledge and the nature of science.

2.3.2 Recommendations Concerning Curriculum Emphases

The challenge to educators, is to determine an appropriate curriculum emphasis and apply it to the subject material - sometimes in spite of a unifying theme presented in

the chosen textbook. Teachers must be aware, not only of textbook emphases, but of their own biases as well. They were educated in secondary schools which very likely presented science through a "nature of science" or a "knowledge foundation" emphasis. It takes effort to fight the temptation to teach in the same manner. Textbooks have only recently started to reflect the different aims of science education.

The main purpose of using a curriculum emphasis as a focus for teaching a unit is to enable students to better understand the concepts by making them more relevant, that is by providing some logical reason for learning the content(12).

2.4 COMPONENTS IN EACH UNIT OF STUDY

The Ministry of Education guidelines specify that the components of every course follow the following format:

* Objectives: Attitudes, Skills, Knowledge
* Student Activities
* Applications
* Societal Implications
* Evaluation of Student Achievement
* Safety Considerations
* Possible Extensions

* Some Teaching Suggestions

The first 6 components are mandatory.

2.4.1 Analysis of components in each unit of study:

Objectives: To accomplish the Aims of Science Education, the Ministry has set out attitude, skills and knowledge objectives for each unit of every science course in the Intermediate/Senior guideline. The attitude objectives are given first, as they are to be "woven into the fabric of the knowledge and skills objectives to underline the fact that science is a human endeavour". Both the attitude and the skills objectives precede the knowledge objectives to emphasise the need to provide time for their development.

Additional components in each unit include mandatory and recommended Student Activities, scientific Applications and Societal Implications.

Student Activities: include mandatory labs or exercises which must be performed by the individual students. An example of a mandatory activity from the O.A.C. Biology guideline comes from the unit entitled The Chemical Basis of Life (see Part II of this report). Students are to "build molecular models of simple carbohydrates, amino acids, simple polypeptides, and functional groups". Equivalent activities may be substituted where the

teacher deems this would be appropriate and desirable. Other activities are described which may be performed by the students themselves, demonstrated by the teacher or discussed in another presentation format. However, if the students do not actually perform the activities, the related scientific concepts must be covered in the teaching of the unit.

Applications and Societal Implications: One of the applications named in the O.A.C. Biology unit referred to above is "Our ability to determine the structure of proteins through genetic research involving DNA has led to the successful production of important enzymes and hormones (eg. insulin)". Note that the language in which these Applications and Societal Implications are written is not in the form of student behaviours. The intent seems to be that the teacher incorporate these wherever possible throughout the unit. If teachers decide any are important enough to be specifically taught for evaluation they must rewrite them as student behaviours and include them with the objectives which they give to their students.

Evaluation of Student Achievement: sets evaluation guidelines including design and performance of experiments, organization of data, interpretation and graphing of data, interpretations of micrographs, work with molecular models, library projects, reports and others. Objectives, student

activities, applications, and societal implications must be evaluated.

This section presents a challenge in that teachers are directed to evaluate not only knowledge objectives, with which they have had much experience, but also skills and attitude objectives. Student behavioral objectives written using terms expressing skill, such as; process, experiences, investigations, searching the literature, storing and retrieving data, and solving problems, have only recently begun to be evaluated. Teachers need to continue to share workable techniques for accomplishing this task. Attitude objectives which involve the student's appreciation, interest, awareness, curiosity, concern, and commitment, represent a whole new realm of evaluation with which teachers have little experience.

This area of student evaluation will be dealt with in more detail in section 3.0 of this paper.

Safety considerations: provides the teacher with precautions appropriate to each unit.

Possible Extensions: describe optional material which may be provided as enrichment for students who need an additional challenge. Students must complete this work independently as no additional time is provided for covering it within the unit.

Some Teaching Suggestions: provides ideas on strategies for teaching each the unit. Teachers are encouraged to utilize their own additional strategies in the teaching of each unit.

2.4.2 Recommendations concerning components in each unit of study

The following recommendations deal only with OAC Biology. In the author's judgement, the time allotted for units in this course is insufficient. The specific number of hours for each unit is intended to allow teachers to cover objectives, mandatory activities, applications and societal implications, as well as evaluation.

There are other factors that affect the amount of time required to adequately cover a unit of study ; student background, requirements for future courses, number and complexity of labs, necessary discussions on sensitive issues and career opportunities etc.

Because of these and other factors, teachers must often compromise " **the goals of education**" to complete a unit of study within the time allotted in the "**curriculum guideline**". For example, goals can be compromised by:

* reducing the depth of treatment for each unit

* selectively omitting material within each unit
* assigning more independent study to students
* shortening or omitting units at the end of the course

The depth of treatment of a unit is determined predominantly by this time allotment. Depth will also be based on other factors - student background, requirements for future courses, number of labs students perform, discussion of career opportunities and sensitive issues, and evaluation time.

The material in each unit can only be covered by one or more of the following:

* reduced flexibility
* reduced depth of treatment
* selective omission of material
* shortened or omitted units at the end of the course

3.0 EVALUATION

3.1 REASONS FOR EVALUATION:

Why do teachers evaluate students? Historically, educators in Ontario have practiced a unidimensional form of evaluation. Evaluation has been defined as "a systematic process

of determining the extent to which educational objectives are achieved by pupils"(13).

There are other reasons for evaluating students. The authors of the OSSTF publication Making the Grade(14) have made a thorough summary of other reasons for evaluation in addition to achievement of objectives. The authors point out that evaluation can also be used to:

> **Diagnose:** Evaluation to diagnose the level of understanding that students have of a topic or the level of skill development students have reached, before further instruction takes place is not done adequately, largely because many teachers lack the skill to develop appropriate diagnostic tests, or because they resist donating the extra classroom time at the expense of content. Teachers have an obligation to identify strengths and weaknesses and to communicate these clearly with suggestions for assistance.

> **Observe level of skill-transfer:** Curriculum now focusses more on cumulative skill development in appropriate areas. An example in science would be in the area of experimentation and report writing. The students skill in this area advances with experience. There is a greater need for diagnostic types of

evaluation which indicate to the teacher and the student those skills which are developed as expected and areas where efforts need to be focussed.

Measure attitudes and appreciation: These can be seen in subjective ways as in, for example, the message in a poster created on an environmental issue. But how does one measure attitude or appreciation? Or should one? Some would argue that if these are written as objectives, they must be evaluated. Perhaps so, but not necessarily in a quantitative way.

Attitude and appreciation can be taught by example and exposure. No one would argue that respect for life or adherence to safety precautions are not desireable attitudes. The former can be emphasized throughout a course in the approach to topics such as dissection. Safety can be evaluated using a specific method during laboratory activities (see later discussion). The attitude objectives must be kept in mind throughout each unit.

3.2 FACTORS AFFECTING CHANGES IN EVALUATION:

Several factors in society and education today have affected program and have a direct bearing on evaluation(15). The **information explosion** of recent years has caused a change in emphasis in curriculum toward more skill development in the area of organising and applying information rather than on content. This takes an effort and a conscious breaking-away from the traditional content-oriented program. It is difficult to change behaviours that have been shaped by how teachers were taught.

The deemphasis on rote learning asks students to use facts and experiences, not as ends in themselves, but as a means to further understand concepts and processes and to make generalizations. Teachers need to evaluate students' abilities in these skill areas, not just on their accumulated body of knowledge.

There is also a greater emphasis on the **active involvement** of the learner in the learning process. The student must take more responsibility for his/her own learning. This means teachers need evaluation methods which measure students' skill in applying their knowledge to new situations and their ability to learn through peer interaction.

Another major thrust in education is a result of our increased **understanding of student growth and development** as it relates to learning. Now teachers need to determine individual

levels of development and evaluate individual knowledge and skill levels. This area is more critical in the younger grades where differences in levels of development are more marked than at the OAC level. However the research does have implications for science curriculum regarding appropriate timing for exposure to science concepts in terms of age or gender. The students readiness for a new level of learning or skill is a major factor in success(16).

There is some indication that female students are ready to learn the basic concepts in the physical sciences at an earlier age than it is currently taught. This makes success difficult at the senior level in high school(17)(18).

The issue of sex stereotyping was a part of the Provincial Review carried out in 1988 in senior physics and chemistry courses(19). The results indicate a change in attitude. In it students indicated that science is equally important for females and males and that women as well as men can be successful in science. Presently there is a larger proportion of female students taking science courses than previously.

The school system and teachers specifically are more **accountable** for effective delivery of education and this has resulted in several changes. Teachers need to gather more detailed information on students' progress and achievement of

objectives. Evaluation techniques and weightings must be clearly indicated with the results communicated to students and parents in a meaningful way. This is as it should be. There should be no surprises or mystery about how a mark is arrived at. Communication and feedback are teachers' primary goals.

3.3 CHARACTERISTICS OF EFFECTIVE EVALUATION

What are the characteristics of an effective evaluation program(20)(21)(22)? There should be a strong and obvious connection between the objectives and the evaluation. The evaluation method, whether it be a test, an assignment or observation of an activity must be actually measuring the student's ability to meet the objectives which have been set. If the objective is written in terms of the ability to analyze information, then the evaluation must not be carried out at the recall level. Students very quickly come to realize what the "real" objectives of a course are, based on how they are evaluated. What and how teachers evaluate tells students what they consider important and value.

Evaluation methods should be varied and consider student strengths and weaknesses(20)(21)(22). A single evaluation method just doesn't supply enough detailed and accurate information about a student's progress. There are many ways that a student learns throughout the course of the year or

semester and all of these should be reflected in the evaluation scheme. Teachers should be as comprehensive as possible. This takes more thought and organization.

3.3.1 Types of evaluation(20)(21)(22)

Informal evaluation is more subjective and anecdotal than the formal methods which teachers are used to and tend to be emphasized more in elementary schools. However, secondary teachers still need to be aware of this type as for example, in the observation of laboratory skills and adherence to safety practices on a day-to-day basis.

Teachers should have an evaluation plan that spans the entire semester which is well thought out and efficiently organized. It should include the three types of evaluation, **diagnostic, formative and summative.** Too often teachers rely solely on summative forms of evaluation. Diagnostic is more informal, and therefore, for many of us more difficult to apply and keep records. Teachers do need to look at underlying causes of learning difficulties and to modify program where possible in the light of individual needs. It helps to know abilities and skill levels of students at the beginning of a unit of study to remedy areas of weakness before continuing on. Teachers do not emphasize this area of evaluation because of time constraints as well as the difficulty inherent in concentrating on individual

students in large classes. Peer tutoring can be of great help in this area.

Formative evaluation is carried out to measure student rate of progress, and provide feedback to the teacher, who can then improve instruction based on effectiveness. At this level, students can take an active part by carrying out self- and peer evaluation. Examples of formative evaluation in science are class tests, homework assignments, lab reports, oral presentations, prcjects, and evaluation of general attitude and behaviour.

Summative evaluation is used to determine the achievement level of a student at the end of a unit or course. It is usually based on methods such as formal examination, major lab practicals, and extended projects. Both summative and formative types should contribute to the student's mark in a balanced manner at the OAC level.

3.4 EVALUATION IN OAC (ONTARIO ACADEMIC CREDIT)

These characteristics of an effective evaluation program have been addressed to some extent in the new science guidelines. OAC course have the following breakdown:(23)

	course components	percentage range
*	laboratory activities and reports	at least 15 percent
*	independent study	at least 10 percent
*	one or more formal examinations	30 to 40 percent
*	term work not included in the above	the balance of the 100 percent assigned

In a general way, this tells teachers that laboratory activities and the accompanying skills, and independent study are important enough to be evaluated. However, these components are not given enough weight. In the individual units, laboratory activities and reports are to comprise at least 30% of the mark. However, in the overall course evaluation breakdown these components comprise a minimum of 15% Unless evaluation of activities and skills acquired in the overall course(see Part 2 of this report)are given a higher mandatory weighting, teachers will be tempted to reduce their weighting in favour of more content-oriented components. Although teachers are free to weigh activity and skill components more heavily if they wish, this is not likely to happen unless the Ministry increases their mandatory weighting.

It should be acknowledged that even at the 15% level, the mandated evaluation scheme for activities and skills has produced an increased focus on evaluation of skill development.

Within the Halton Board, this has produced a significant increase in laboraory activity performance by students in science courses. Too often in the past, an experiment was only demonstrated, or discussed and not performed, hence there was little or no opportunity for development of laboratory skills.

3.5 EVALUATION TECHNIQUES

Teachers must look closely at the technique of first-hand observation as a method of evaluating student performance of a skill. This type of evaluation is difficult to quantify and teachers tend to avoid it.

A logical and practical approach to this type of evaluation has been suggested by the authors of Making the Grade(24). They suggest an evaluation plan that focusses on a small number of students for a manageable period of time. This enables the teacher to quantify the performance of behaviours. The criteria for evaluating these behaviours should be few in number, spelled cut in advance, and take only a brief time to complete. A checklist with a rating scale is a useful way of focussing on the chosen criteria. Student activities could be videotaped. Ideally, another person would carry out the videotaping in order to free the teacher to act as resource person during the activity. This is particularly appropriate for

important activities which are only going to be performed once. The teacher can be assured of observing all students. There is an obvious time requirement involved in reviewing the tape, but this offers flexibility as to when the evaluation can be carried out.

Once teachers have observed and evaluated the students in this manner, they should quickly encourage and improve student skills.

In the summative mode, final achievement of skills for a course can be evaluated using methods such as dissection or "bell-ringer" lab practical exams. Again, it must be stressed that the objectives and the method of evaluation be communicated clearly to students.

4.0 CONSIDERING THE STUDENT AND INDIVIDUAL NEEDS

The Ministry guideline does address the special needs of exceptional students, however comments will concentrate on individual learning styles and recommended strategies for the classroom. Strategies are general and are applicable to most students.

The authors of Teaching and Learning Styles(25) remind teachers that traditional teaching which stresses lecturing and

the socratic method ignores other learning styles prevalent in the classroom. Teachers who consider different learning styles can work with the strengths and weaknesses of most students.

There has been a recent surge in understanding of learning styles as a result of research into brain development and hemisphericity (dominance of the left or right cerebral hemispheres)(26)(27). Different authors have devised schemes for categorizing and teaching to different learning styles. For example, Samples, Hammond and McCarthy(28) describe a Learning Modalities framework which represents the widest range of sensory input; visual, auditory and kinesthetic. Each of these sensory inputs represents a different learning style or "modality". The authors observed that students who are visual learn best through observation. They respond well to diagrams and charts. Auditory learners learn best through the spoken word, listening to tapes and discussing. Kinesthetic learners learn by "doing". The need to physically move around and try things out. Laboratory activities are ideal for this group.

By means of questionnaires, teachers can discover an individual's dominant modality. This is not to say that learning cannot be transferred from one modality to another or that one modality is used in all situations. However, it is useful to be aware of the range and proportion of modality strengths present in the classroom to better structure modes of presentation.

Statistics generated as a result of testing 630 Acton High School students in 1988 are interesting in this respect (see Fig. 1).

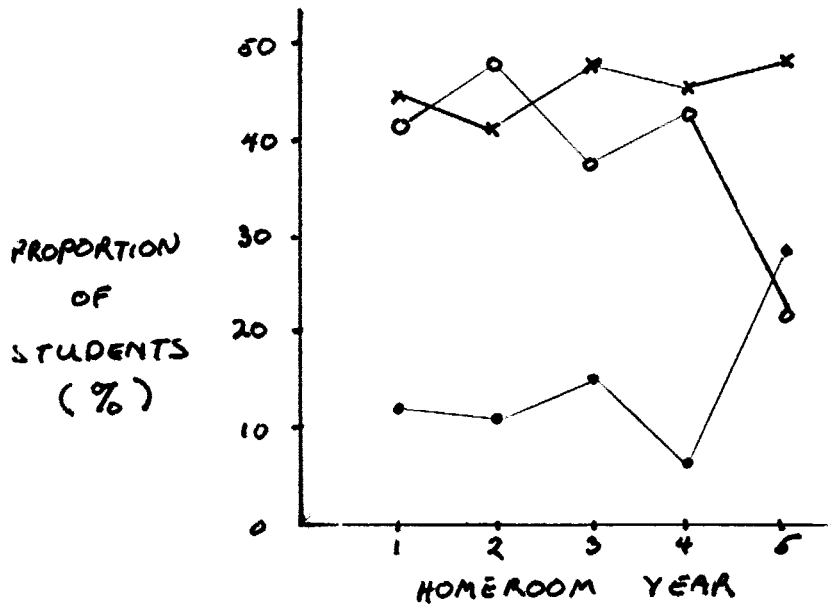

Fig. 1 Graph Showing Distribution of Dominant Learning Styles by Homeroom Year.

There is a marked contrast in the proportion of learning styles between the first 4 years of high school and the OAC year. The kinesthetic modality drops drastically and the auditory modality increases greatly. It is interesting to speculate on the possible reasons for these differences. Perhaps the OAC

students have been selected by nature of our educational system. Students who are auditory or visual do well at the OAC level. Most teachers seem to prefer either of these modalities. There is some evidence to dispute the idea that kinesthetic learners are unsuccessful(29). This shows that there seem to be enough activities in the classroom that appeal to students who like to learn by doing. This should be particulary true in science classrooms.

The statistics, although based on a reasonable sample size, do not represent hard data. Students completed the questionnaire in class. It asked questions about situations in which students best learned subject matter. How a student best learns mathematics may be different from visual arts. There may be bias as a result of the particular class students were in while participating in the survey.

It is important for teachers to be aware of student differences, as well as their own biases and learning preferences. A variety of presentation methods should be used to allow students to best process information. This will also help students to compensate for a weaker learning style (see Appendix 4).

5.0 THE DESIRABLE CHARACTERISTICS OF GRADUATING STUDENTS

5.1 INTRODUCTION:

Throughout the experience of educational process, students should acquire certain desirable characteristics. But desirable according to whom? The Ministry? The Board? The school? Or the teacher? It makes sense to define these "desirable" characteristics so that our programs can nurture them.

5.2 CHARACTERISTICS ACCORDING TO THE MINISTRY OF EDUCATION:

The authors of the Program and Policy statement of the science guideline have formulated a list of these characteristics (see Table 4 below):

Table 4: The Image of the Successful Science Student (30)

The science student , whether or not he/she aspires to be a scientist or technologist, should acquire the following characteristics:

a) an interest in natural phenomena and technology

b) an ability to understand scientific concepts and the nature of science

c) a capability for applying investigative processes and manipulating laboratory apparatus

d) a capacity for the retention of scientific and technological knowledge

e) mathematical expertise

f) some resourcefulness and creativity in learning

g) a comprehension of the language, vocabulary, and symbols of science

h) a sense of self-worth and respect for other people's ideas and opinions

i) acuity in distinguishing fact from fiction

j) a willingness to apply learning in science to everyday life

k) a developing sense of ethical values that relate to scientific advances and increasingly sophisticated technology

Comment: Note that the student "<u>should</u> acquire" these characteristics, not "<u>will</u> acquire" them. In the author's view, there are many successful science students who have not acquired all of these characteristics, for example, mathematical expertise (what level of expertise is desired here?) At the OAC level there is higher percentage of students who intend to be scientists or technologists.

However, characteristics important to these careers, such as resourcefulness and creativity in learning, may never be acquired by some of these students. There are other

characteristics which teachers should strive to instill in all their students whether they will continue in science or not.

These include a **questioning attitude.** Teachers should foster student inrate curiosity, not dampen it with pat answers. Students should not just blindly accept views of others or accept the status quo. Each student has the ability to challenge a behaviour or a situation and the obligation to make his/her voice known (eg. writing a letter to the editor of a newspaper or speaking to a store manager about excess packaging).

The ability to view the activities of scientists and technologists as an integrated part of our society: Students should be able to see the implications to society of scientific and technological developments and be able to formulate their own judgments about the desirability of these, including possible benefits or harmful effects. They must be able to analyze information as presented by the various media and be able to detect bias. Their judgments must be made from a basis in information and analysis of all sides. Related to this is the ability to use their own values as a yardstick (metrestick?) against which to measure their own behaviours. Whether or not they are attainable in every student, these are worthy goals.

In addition to the "desirable characteristics" recommended by the Ministry teachers must deal with

characteristics subscribed to by their boards of education. These are of a general nature and echo the "motherhood" flavour of the goals of education presented at the beginning of this paper. Many schools are beginning to define their own education goals based on Ministry goals (see Appendix 3 for the Halton Board of Education and Acton High School Goals).

Why go through the exercise of defining specific characteristics which educators would like to instill in students? If an activity or method of teaching used in a classroom does not develop "desirable characteristics", it should be seriously questioned - or perhaps the characteristic itself needs reexamination. Staff should have input into the definition of these characteristics in a manner which promotes continued support and alignment with the goals of individual schools.

5.3 TEACHING TO PROMOTE THINKING SKILLS:

Although all are desirable, some of these characteristics are more "teachable" than others. For example, how do teachers promote thinking skills?

Wasserman and Zola (31) observed that, although teachers say teaching to promote thinking skills should be a priority, in reality there is an "underwhelming emphasis" on this in schools.

While teachers may believe they are promoting thinking, they may in fact, be inhibiting thinking. These two authors make practical suggestions toward promoting thinking in classrooms. They recommend that teachers choose activities which require enquiry on the part of students, and that teachers interact with the students in a way which promotes thinking.

The authors suggest 7 criteria making an appropriate choice of activity:(32)

1. Is this activity worth thinking about? Does it have significance?
2. Does the activity promote open enquiry?
3. Is the activity appropriate to the intellectual abilities of my students?
4. Does the activity allow for a wide range of possible responses?
5. Will the activity lead to new insights and awareness?
6. Will the activity provoke the students' curiosity, engage their attention, sustain interest?
7. Does the activity allow the students to do most of the thinking?

These criteria are difficult to apply to most published OAC laboratory exercises. Promoting thinking skills necessitates rewriting or originating activities. There are activities

mandated in the OAC Biology guideline which require students to design experiments. This takes more class time and a greater variety of laboratoy equipment than is currently available. Teachers will have to guide students while at the same time resisting the urge to give them a recipe aimed at the "correct" result. The outcome in quality of education for the student is worth the extra effort.

While students are carrying out the chosen activity, teachers should ensure that their interaction promotes thinking. Responses which inhibit thinking are those that (1) direct answers, (2) provide information or right answers, or (3) present the teacher's point of view. The point is that teachers should select responses that encourage thinking skills at appropriate times. Teachers should be aware of their own relative proportions of each type of response. When they agree or disagree with a student, show him/her what to do, restrict the amount of time they allow for an answer, or put down ideas, they are inhibiting thinking.

It is important that the classroom has an atmosphere that promotes questioning without fear of ridicule or sarcasm. Teachers should not do all the thinking for the students and they should allow them the time and freedom to formulate their own ideas.

Responses that extend thinking are those which ask for more data, ask for the student's ideas, ask for analysis, ask for predictions or raise a new idea. Teachers who have open classrooms where there is free exchange respond this way more frequently. Students feel free to take risks.

Self-analysis is difficult for most teachers. Wasserman and Zola suggest a practical method for evaluating and analyzing teachers' responses. Using an appropriate activity, they suggest that teachers tape records their interaction with students for about 15 minutes. They provide a worksheet for classifying responses and then analyzing the nature of the responses.

Learning to promote thinking will be difficult for teachers steeped in a content-oriented science background. They will have to unlearn many behaviours. This takes effort and committment. Society will benefit from this by gaining more thoughtful, autonomous individuals.

6.0 GENERAL COMMENTS ABOUT OAC BIOLOGY:

The new Ministry OAC Biology guideline is extremely ambitious. In the author's judgement it may be overly

ambitious resulting in a number of problems at the practical level:

There is too much detail in the objectives of each unit. For example, in the Plant Physiology and Photosynthesis unit, students are to "explain the role of photosynthetic pigments and compare the structure and absorption spectra of chlorophylls a and b". The concept of the role of the pigments and wavelengths they best absorb are valuable. However, in the author's view, being able to reproduce the absorption spectra characteristic of each of the chlorophylls does not add to the understanding of the concept.

The author has observed that many teachers have continued to use elements of the previous guideline in their courses. Teachers will need to "let go" of favourite topics taught under the previous guideline. This should help with the time constraints. Boards of education should provide inservice training for teachers to clarify the new guideline, identify problems areas and propose solutions.

In its present form there is no apparent unity or theme to the units. This is evident in the unit titles:

(1) Chemical Basis of Life

(2) Energy and the Living Cell

(3) Plant Physiology and Photosynthesis

(4) Homeostasis

(5) Genetics

(6) The Theory of Evolution

(7) Ecology

One way to weave a story-line through the course is to use evolution as a unifying theme. This is logical because the concepts of adaptation and natural selection have application in each unit. For example, in the Chemical Basis of life, teachers can discuss enzymes all organisms share and in the Genetics unit, teachers can explain the universality of the genetic code.

Due to external factors the Ecology unit as outlined in the guideline is likely to be given inadequate treatment. Many of the OAC ecology concepts have already been covered in grade 10 science. OAC Biology should build on these simple concepts of food web, niche, population etc.

The OAC activities are general in nature. For example, students are to "measure environmental factors and interpret the data obtained in terms of the effects of such factors on populations of organisms". The list of possible environmental factors and their effects is extensive and

requires considerable background in ecology to design the activity.

Few teachers have adequate background in environmental topics to feel comfortable with this unit. For this reason, boards of education should provide in-service training.

Some mandatory laboratory activities are difficult to perform with available laboratory equipment. The value of some of the activities is unclear. For example, in the Plant Physiology and Photosynthesis unit, students are to " Prepare and examine wet mount slides of algae or leaf tissues to identify the location, shape, size and quantity of chloroplasts." It is difficult to slice sections thin enough using high school laboratory equipment.

In this situation, the variables to be studied are more clearly seen using prepared slides. In other activities, teachers will need to find substitute activities which present the same concepts as the mandatory activity without requiring expensive equipment.

Teaching the OAC Biology course successfully requires

teachers to consider many factors while designing and presenting the course:

The new thrusts in the guideline (such as attitudes, societal implications and applications) will direct teachers away from strict recall of subject material toward higher order thinking skills such as comprehension, synthesis, and analysis.

Teachers will need to design new evaluation instruments which address practical skills such as microscope and dissection techniques. Students will be asked open-ended questions which are designed to test their comprehension of concepts and require them to make judgments.

Students should be taught ways of researching acquiring knowledge, and solving problems which they can extend into adulthood and apply to situations they will encounter throughout life. They are the future opinion-makers, consumers and voters of our society.

PART 2

OAC BIOLOGY COURSE OF STUDY

INTRODUCTION

This section includes suggested curriculum emphasis, objectives and resources and evaluation breakdown for each unit of study within the OAC Biology course. Unit objectives have been grouped by key idea. The format is intended to be used by students. The first 7 units are mandatory and the final unit involves the choice between Animal Behaviour or Independent Research. The latter option will be used to promote skills development and encourage problem solving through design and execution of an individual experiment or study.

Unit 1 Chemical Basis of Life

Curriculum Emphasis: "Knowledge-foundation emphasis" (see Table 2 and Appendix 1)

Rationale: Students must master topics in this unit in order to understand material in later units dealing with DNA and protein synthesis, respiration and photosynthesis. Most of them have had some exposure to chemistry because schools generally recommend Grade 11 chemistry as a prerequisite to OAC biology. This is not a Ministry prerequisite, however. Many students do find

chemistry intimidating and the more 3-D models and daily life examples used, the more students will understand the concepts.

Later units assume students understand the concepts in the objectives for this unit, such as storing energy in bonds, and differing bond strengths. It is important that they receive a good grounding in this unit.

Objectives and Resources

Key Idea: It is impossible to delete the study of chemistry from modern biology. Atoms and their interactions play a central role in the study of life and living processes. It is important that a review of chemical terminology and concepts be conducted. The relationship of these concepts to life should be attempted where and whenever possible. (West-Central Interboard Science Consortium, 1988)

(N.B. Page references will refer to the text Understanding Biology by Raven and Johnson, 1988 unless otherwise noted. Kimball refers to Biology by Kimball, 1985 and J.J. Head refers to A Student's Collection of Micrographs, 1987)

(Objective Type designated as K = knowledge, S = skill, A = attitude, Ap = application, So = societal implication)

Objective		Resource
1.K	Explain the meaning of the following terms; atom, ion, isotope, electronegativity	p.37-40 Kimball p.36
2.K	Explain the meaning of the following terms; molecule, pure substance, mole, chemical reaction	p.29,47
3.K	Explain in terms of electronegativity and stable electron configurations why atoms interact	p.39,40
4.K	Describe the formation of the following bonds between atoms; ionic, covalent, polar covalent, hydrogen	p.40-43
5.(F)K	Describe the structure and properties of hydrophobic and hydrophyllic molecules	p.45-46
6.K	Explain the meaning of the following terms; acid, base, pH, buffer	p.47-48
7.K	Identify and describe examples of oxidation and reduction reactions that occur in	p.133-134

living organisms

8.K Explain the concept of bond energy and use this concept to account for exergonic and endergonic chemical reactions — p.129-135

Key Idea: A thorough grounding in organic chemistry - the structure of carbon-based compounds, their properties, their reactions and subsequent bonding is necessary to fully appreciate biochemical structures and events. (Science Consortium, 1988)

Objectives	Resources
1.K Explain the meaning of the following terms;	p.48-49
2.(F)K Differentiate between structural and stereo isomer	p.49-50
3.S Construct molecular models of simple carbohydrates, amino acids, simple polypeptides, and functional groups	activity sheet
4.A Appreciate the use of scientific models and theories related to atoms and molecules in visualizing the structure of biological molecules	

Key Idea: Many organic molecules are directly linked to the structure, function and diversity of living things. Life as we know it evolved from the interactions of various organic molecules. The nature, biological importance, and the origin of proteins, carbohydrates, fats, and nucleic acids can be traced and studied. The influence of the environment on these bio-organic molecules should be appreciated. (Science Consortium, 1988)

Objectives		Resources
1.K	Describe using representative examples and structural formulas, the general structural features, the key subgroups, functional related linkages, and the main functions in living organisms of; carbohydrates, lipids, proteins and nucleic acids	p.49-60
2.(F) K	Differentiate between fats, oils and steroids	p.54
3.K	Describe the components of protein structure and the importance of this structure in the role of such biologically active proteins as enzymes and hormones	p.57-59

4.K	Compare condensation and hydrolysis reactions and describe their role in the synthesis and degradation of polymers	p.53 Kimball 53, 58,63
5.(F)	Write chemical equations for the reactions in number 4 above	p.52-53
6.S	Make solutions that have specific concentrations	student lab
7.S	Measure the pH of solutions	student lab
8.S	Design and perform an experiment to investigate the action of enzymes and factors that affect enzyme activity	student lab
9.Ap	Understand that the nutrition of organisms should include proteins, carbohydrates, lipids, vitamins, minerals, and water	p.645-649
10.Ap	Understand that our ability to determine the structure of proteins through genetic research involving DNA has led to the successful production of important enzymes and hormones (eg. insulin)	discussed further in Unit 5 Genetics

11.So Realize that greater knowledge of biochemical processes has led to significant advances in medical procedures and health care generally

12.So Realize that through an understanding of biochemical processes theories that attempt to explain aging have been formulated

13.A Develop curiosity about the biochemistry of cellular processes

14.A Develop an interest in the biochemical nature-of-life processes

Evaluation

*	Factors affecting enzymes lab	10
*	model building exercise	10
*	pH and salivary amylase lab(student design)	20
*	determining pH of household substances	10
*	quizzes 2 @ 10	20
*	unit test	70

Ministry Guidelines

At least 30% of the term mark for this unit is to be based on students'

a) design and performance of experiments

b) organization of data from experiments

Unit 2 Energy and the Living Cell

Curriculum emphasis: "Nature-of-science"

Rationale: Students have covered the topic "the cell" in grade 9 and in grade 11 biology. It is useful to review the cell theory and its historical development as a backdrop to the more detailed study of cell membrane and mitochondrion function in this unit. It places recent developments in our understanding of these structures in a historical context and emphasizes how models and theories of "how things work" change with time and added information provided through new technologies.

The impact of the microscope on cytological study should be emphasized. From this we can progress to the wealth of detailed information the electron microscope has provided. Among other things, we can now distinguish between prokaryotes and eukaryotes.

It does not make pedagogical sense to study the plasma membrane and mitochondrion in isolation. The nature-of-science emphasis provides a relevant context.

Objectives and Resources

Key idea: Each cell structure has a function. It is necessary to review the basic cell organelles and to study similarities between prokaryotes and eukaryotes before continuing on to a more in depth study of the functioning of the cell membrane and mitochondrion later in this unit. This will give a preliminary overview. The development of optical lenses and the E.M. led to major advances in cytology.

Objective		Resource
1.F K	State the cell theory	p 78-9
2.F K	Understand why cell size is limited	p 79,82
3.F K	Describe the contribution of Van Leeuwenhoek to cytology	p 79
4.F K	Compare and contrast the light microscope and E.M. in terms of illumination resolution and viewing conditions	p 80
5.F K	Differentiate between prokaryotic and eukaryotic cells	p 82-84
6.F K	Describe the structure and basic function of major eukaryotic organelles	p 85-101
7.F K	Evaluate the prokaryotic origin of mitochondria and chloroplasts hypothesis	p92,94
8.F	Place cells in a hierarch of organi-	teacher

K	sation	
9.F	Comprehend that cells and their organelles are dynamic and interact to perform the functions of life	
10.F	Understand that cells do not act in isolation but that materials move within a cell and are exchanged with the environment	
11.F	Recognize cell organelles and interpret dimensions from electron micrographs	J.J.Head (26)

Key Idea: Explain how a model for the cell membrane, such as the fluid mosaic model, accounts for experimental data relating to the structure of the cell membrane and the observed movement of materials through the cell membrane. Investigate the effect of environmental factors on this movement.(Science Consortium, 1989)

Objective		Resource
1.S	Interpret the detailed structure of cellular membranes from electron micrographs	J.J. Head
2.A	Develop an appreciation of the relationship of structure to function in cell membranes	
3.F	Define diffusion and osmosis	p 112-113
4.K	Define active transport. Use a	p 117

	current theory to explain observations from experimental work	
5.K	Explain how a model for the cell membrane such as the fluid-mosaic model, accounts for experimental data relating to the structure of the membrane and the observed movement of materials through it	p 106-111 p 114-119
6.A	Develop an appreciation of the use of scientific models to help visualize and understand the function of cells.	
7.So	Understand that knowledge of the structure and function of cell membranes has increased our understanding of the effects of poisons and bacterial toxins, and has been applied effectively in cancer research and treatment	
8.S	Design and perform experiments to investigate the effects of environmental factors on the movement of materials through the cell membrane	
9.K	Explain the effects of temperature, pH, and the type and concentration of solute on the movement of materials through membranes	p 112-120
10.S	Interpret and graph data from experiments on the movement of material through membranes	
11.F A	Appreciate the role of the cell membrane in maintaining homeostasis	
12.Ap	Recognize that cell types in individuals are	p 121

unique because of membrane structure and that cell identity relates to tissue and organ transplants

Key Idea: Cells need energy for metabolic activities. The mitochondrion performs this vital function by virtue of its structural design. Organisms obtain this energy from food and transform it into useful energy in the mitochondrion.

Objective		Resource
1.S	Interpret the detailed structure of mitochondria from electron micrographs	J.J. Head
2.A	Develop an appreciation of the relationship of structure to function in mitochondria	p 157
3.K	Explain the terms: metabolism, catabolism anabolism, aerobic metabolism, anaerobic metabolism	glossary
4.K	Describe the synthesis of ATP and its use in the cell	p 146-148 p 140-141
5.K	Describe, in general terms, how the first and second laws of thermodynamics apply to energy use and transformation in the biosphere and in the living cell	p 130-132
6.S	Design and perform experiments to investigate the catabolism of food materials in cells	
7.S	Interpret and graph data from experiments	student lab

	on catabolism in cells	
8.F K	Compare and contrast endergonic and exergonic reactions	p 134-135
9.F	Describe the dynamics of biological oxidations and their transfer of energy in cells	p 133-134
10.K	Describe the relationship between glycolysis, the citric acid cycle, and the electron transport chain and for each indicate the reactants, products and location in the cell	p 148-159
11.F K	State the chemical equation for oxidative respiration of glucose	p 159
12.F K	Given a skeleton diagram, indicate the name of compounds in the glycolytic pathway and in oxidative respiration	p 151,154
13.F	Explain how the electron transport chain operates to produce ATP using the chemiosmotic theory	p 156-158
14.F	Compare and contrast anaerobic and aerobic respiration	p 160-161
15.K	Explain and compare the release of energy and the production of ATP that results from anaerobic (Glycolysis and lactic acid fermentation) and the aerobic (citric acid cycle) catabolism of glucose	p 158-159 p 150

16.F K	Recognize the importance of the hydrogen acceptor in carbohydrate fermentation	p 160-61
17.K	Explain the significance of anaerobic catabolism and the build up of lactic acid in active muscle tissue resulting in muscle fatigue	p 160-61
18.Ap	Understand that knowledge of anaerobic catabolism in active muscle tissue provides an understanding for muscle fatigue and oxygen debt, and has generally contributed to better conditioning techniques	
19.So	Realize that industries whose products are based on the fermentation process make an important contribution to the economy	
20.Ap	Understand that the preparation of a number of common foods and beverages (baked goods, dairy products, vinegar) involves the use of the fermentation process and has led to the development of substantial industries	
21.K	Describe in general terms, how derivatives of fats and proteins can be used to produce usable energy by entering the glycolytic and citric acid pathways	p 153 Kimball p 143-44
22.Ap	Realize that application of our knowledge of the cell has led to improved medical, dietary, and physical fitness procedures	

Evaluation

*	Investigation of osmosis with egg lab	10
*	Interpreting electron micrographs	5
*	Factors affecting movement across membrane lab	10
*	Investigation of products of anaerobic catabolism lab	10
*	Investigation of products of aerobic catabolism lab	10
*	Quizzes 2 @ 10	20
*	Unit test	70
		135

Ministry Guideline

At least 30% of the term mark for this unit is to be based on students'

a) laboratory experiments

b) interpretation and graphing of data from experiments

Unit 3 Plant physiology and Photosynthesis

Curriculum Emphasis: "Nature-of-science"

Rationale: As in the previous unit the historical perspective of the pathway to our current understanding of the nature of photosynthesis demonstrates the changing nature of science. Photosynthesis is fundamentally important and this should be emphasized. It is important that the biological concepts and principles not get lost in a maze of chemical details.

Key Idea: Explain the role of photosynthetic pigments. Examine the photosynthetic processes of light and dark reactions (Science Consortium, 1988)

Objective		Resource
1.F A	Appreciate that life on earth depends on transduction of photon energy in sunlight to chemical energy in food by green plants	p 165
2.A	Appreciate that the needs of the biosphere are met ny the complementary , homeostatic processes of photosynthesis and respiration	p 165
3.K	Explain the role of photosynthetic pigments and compare the structure and absorption spectra of chlorophylls a and b	p 167-69
4.F K	Describe the contributions of early investigators to our understanding of photosynthesis	teacher
5.K	Describe in terms of photosystems I and II and the chemiosmotic theory of ATP synthesis	p 171-175

	how light energy is converted into chemical potential energy of ATP and NADPH + H+ during the light dependent reactions of photosynthesis	
6.K	Describe the techniques used by Calvin to determine the carbon fixation (C3) cycle	p 176
7.K	Describe how the ATP and NADPH + H+ from the light-dependent reactions are used to fix carbon and produce phosphoglyceraldehyde in the Calvin cycle	p 176-79
8.K	Describe, including appropriate comparisons to aerobic catabolism, how PGAL can be used to produce glucose, sucrose, starch and other products	teacher
9.K	Compare in general terms the "light" (light-dependent) and "dark" (light-independent) reactions of photosynthesis	teacher
10.K	Describe, based on evidence from experiments and in terms of the relationships between the light-dependent and light-independent reactions, how the rate of photosynthesis is affected by carbon dioxide concentration, temperature, and the intensity, quality and duration of light	teacher
11.K	Recall the structure of the chloroplast and describe the locations where light-dependent and light-independent reactions	p 178-80

take place

12.S Design and perform experiments to investigate the effects on the photosynthetic process of variations in one or more of light quality,intensity, or photoperiod, carbon dioxide concentration, and temperature

13.S Observe the structure of chloroplasts using electron micrographs — p J.J.Head

Key Idea: Discuss the plant structures involved in photosynthesis both peripherally and directly. Discuss the transport of materials through the plant to and from the leaf and movement within the leaf.(Science Consortium,1988)

Objective		Resource
1.F K	Describe the structure of xylem and phloem tissue	p 563,566
2.K	Describe how materials are transported throughout plants in xylem and phloem tissue	p 591-596
3.S	Examine prepared slides and/or electron micrographs of leaf sections to study stomata, the structure of chloroplasts and the location and structure of various leaf tissues	J.J.Head
4.K	Describe the structure of a leaf, the role and operation of the stomata and the role	p 568-69

each different kind of leaf tissue plays in photosynthesis

5.S Prepare and examine wet mount slides of algae or leaf tissue to identify the location, shape, size and quantity of chloroplasts

Evaluation

*	Microscopic examination of plant material using to study chloroplasts lab	10
*	Microscopic examination of leaf sections lab	5
*	Examinations of electron micrographs of leaf structure exercise	10
*	Design and performance of experiment investigating factors which affect photosynthesis	10
*	Quizzes 2 @ 10	20
*	Unit test	75
		130

Ministry Guideline

At least 30% of the term mark for this unit is to be based on students'

a) laboratory techniques and experiments

b) interpretation of data from experiments

c) designs of experimental investigations

Unit 4 Homeostasis

Curriculum Emphasis: "Life-management" emphasis

Rationale: The physiological applications possible in this unit will relate the content to the daily lives of the students. An understanding of health and medicine, patterns in the functioning of organ systems will help to enrich their lives.

Key Idea: Define and explain the importance of controlling and maintaining a homeostatic condition.

Objective		Resource
1.K	Define homeostasis and explain in general terms why the maintenance of a stable internal environment is so important to living organisms	glossary teacher
2.A	Develop an appreciation of the need for control and stability in the external and internal environments of living things	
3.Ap	Understand that the need to maintain internal homeostasis may lead to maintenance of good health and good habits (eg. consumption of foods containing essential minerals and vitamins	

Key Idea: Identify the structures of the nervous system. Explain the relationship between the structure and function.

Stress the importance of the nervous system in maintaining a homeostatic state.

Objective		Resource
1.S	Identify the main parts of a vertebrate nervous system	rat dissection sheep brain
2.K	Describe the structure of a neuron	p 702-3
3.K	Explain how nerve impulses travel along and between neurons	p 703-709
4.K	Describe briefly the structural relationships and role of components of the nervous system including the major sections of the brain	713-15 p 718-720
5.K	Explain the concept of a control system using the following terms: receptor, control (interpretation) center, afferent and efferent pathways, effector,response, and feedback (positive and negative)	p 713-720
6.F K	Describe how environmental stimuli are transduced into nervous impulses by sense receptors such as the ear and the eye	p 724-727
7.F	Describe how lenses can be used to correct vision defects	p 727
8.K	Describe the structure and function of a reflex arc	p 729

Key Idea: Identify the structures of the endocrine system. Explain the relationship between structure and function. Stress

the importance of the endocrine system, by using specific examples, in maintaining a homeostatic state(Science Consortium,1988)

Objective		Resource
1.S	Identify the main parts of a vertebrate endocrine system	rat dissection
2.K	Explain the following terms: endocrine gland, hormone, target organ	glossary teacher
3.K	Describe the source (including the location of the gland) and the role of any two interrelated hormones, for example, thyroxin, parathyroid hormone, insulin, glucagon, thyroid stimulating hormone, antidiuretic hormone, adrenaline, noradrenaline cortisone, aldosterone, sex hormones	p 736-40 p 742-745 p 764-766
4.K	Describe the cause, effects, and treatment of one or more of the following: diabetes mellitus, diabetes insipidus, hyper- and hypothyroidism, goiter, Addison's disease	p 745
5.K	Describe briefly the work of Banting, Best and Selye	
6.Ap	Understand that knowledge of the location, role, structure, and function of control systems in the body has allowed for the identification and treatment of various disorders (eg. insulin for diabetes, dialysis for	

kidney breakdown)

Key Idea: Relate the nervous and the endocrine systems to other homeostatic controls eg. kidney, blood etc.(Science Consortium, 1988)

Objective		Resource
1.A	Develop a curiosity about the organs and mechanisms involved in homeostatic control in humans and other living things	
2.A	Develop an appreciation of the fact that most body functions contribute in a co-ordinated fashion to the maintenance of internal stability	
3.S	Recognize and demonstrate biological control systems	
4.K	Describe using the body's reaction to a stimulus such as physical exertion, how the nervous and endocrine systems interact to compensate for temporary fluctuations in the body's internal environment	teacher
5.K	List and describe in general terms, the components of the following: nervous system, endocrine system, kidney, blood,liver	p 742-46 p 755-757
6.S	Perform experiments to demonstrate the action of homeostatic mechanisms in humans	lab
7.S	Measure, record, and graph data from experiments designed to explore homeostatic	

mechanisms

8.Ap Understand that techniques for keeping warm teacher in the winter and cool in the summer are based in part on a knowledge of the body's physiological response to temperature extremes

9.So Realize that medical advances in the treatment of disorders of the nervous and endocrine systems have improved the quality and longevity of life for many.

Key Idea: Discuss the chemical influences on the nervous and endocrine systems.(Science Consortium, 1988)

Objective	Resource
1.A Develop a commitment to learn about and practice health and eating habits that promote the proper maintenance of internal stability	
2.Ap Understand that the discovery and use of psychoactive drugs has had both positive (medical use to relieve pain) and negative (drug abuse and addiction) effects	
3.Ap Understand that steroids(androgens) have been used recently for therapeutic purposes (eg increased body weight and muscular strength in athletes)	

4.Ap Understand that menstrual feedback systems can be artificially manipulated using hormones to increase or decrease the possibility of conception p 766

5.So Realize that medical use of psychoactive drugs has been beneficial but drug abuse and addiction is a major problem in society

Evaluation

* 2 human physiology labs 20
* heart rate lab (Daphnia) 10
* dissection diagrams 10

NB. dissection will be examined in the final lab practical

Ministry Guidelines

At least 30% of the term mark for this unit is to be based on students'

a) descriptions of vertebrate nervous and endocrine systems

b) laboratory experiments and reports

Unit 5 Genetics

Curriculum Emphasis: begin with "Science-as-a-human-endeavour" and follow with "Societal-values" emphasis

Rational: Nothing in biology is more fundamental or ubiquitous than DNA. The history of the discovery of its importance makes for an interesting and exciting story. Genetics can be understood at the molecular level when students understand the relationship between DNA, RNA, proteins and heredity. The implications of our new-found understanding in genetic engineering and prenatal diagnosis should be discussed in light of how these decision affect us as individuals and as a society.

Key Idea: Examine the structures of the biochemical molecules DNA and RNA. Describe the replication of DNA and examine the functional relationship between the two molecules.(Science Consortium, 1988)

Objective		Resource
1.K	Recall the meaning of the terms: gene allele, dominance, incomplete dominance, mitosis, meiosis, heterozygous, homozygous, monohybrid and dihybrid cross, sex-linked trait	p 215
2.K	Describe how the experiments of at least 3 biologists (eg. Mendel, Feulgen, Mullen, Griffith, Hershey, Chase, Watson, Crick, Stahl, Meselson, Chargaff, Sutton, Morgan)	p 244-49 p 250-51 p 251-52

	have contributed to our understanding of genetics	
3.S	Use recombination data from test crosses to determine the linear sequence of 4 or more linked genes	p 218-19
4.S	Analyze electron micrographs of chromosomes and DNA molecules	J.J.Head
5.K	Describe the molecular structure and configuration of DNA	
6.F K	Describe the contribution of Wilkins and Franklin to the Watson and Crick model of DNA	
7.K	Describe the process of DNA replication	p 276-77
8.S	Build molecular models to demonstrate the structure and replication of DNA	
9.F K	Describe the work of Beadle and Tatum which led to the one gene-one enzyme hypothesis	p 252-4
10.K	Explain in general terms how the genetic information encoded in DNA controls the activities of the cell and the growth and development of the organism	teacher

Key Idea: Describe how proteins are synthesized using current theory. Encourage students to appreciate how environmental influences can affect this process.(Science Consortium, 1988)

Objective		Resource
1.K	Describe the structural and functional	p 264

relationship between DNA and RNA

2.K Compare the structure of DNA and RNA p 264

3.K Describe using current theory, including information on transcription, translation, m-RNA, and ribosomes, how proteins are synthesized in the cell p 265-73

4.S Demonstrate using molecular models, aspects of protein synthesis such as the building of m-RNA, the linkage of t-RNA on m-RNA and the relationship between m-RNA and the ribosome

5.K Describe with reference to environmental influences and more specifically, regulatory genes, how the synthesis of proteins might be triggered and repressed and why such control is necessary p 273-76

6.K Describe how mutagens such as radiation and chemicals can change the genetic material in cells by causing mutations eg. frameshift, point mutations and changes in chromosome number p 281-86

7.A Develop an appreciation of the fact that many of the differences among humans result from genetic variability and environmental influences

Key Idea: Describe techniques of genetic research and technology that make genetic engineering possible.(Science Consortium,1988)

<u>Objective</u> <u>Resource</u>

1.K Describe briefly one or more techniques of genetic research that make genetic engineering possible, eg. the use of restriction enzymes to analyze genes, the use of reverse transcriptase to synthesize DNA from RNA, and the synthesis and cloning of recombinant DNA p 294-299

2.K So Describe briefly the following phenomena and outline social benefits and risks of one or more of them:

-gene modification and insertion in prokaryotes in order to produce useful biochemicals

-production of desirable hybrids of domestic plants and animals through genetic engineering

-possible modification and selection of genes in humans

-application of DNA technology in the diagnosis of prenatal and postnatal genetic diseases

3.A Develop a commitment to learn about ethical and moral issues that stem from current research and technologies in genetics

4.S Report using a variety of references on one or more aspects of current genetic research

5.Ap Understand that technological advances in the selective breeding of domestic animals through the use of sperm banks and artificial insemination and through embryo transplants has led to the development of hybrids with

special desirable characteristics

6.Ap Understand that genetic engineering has made possible the development of new biotechnical industries

7.So Realize that the development of new hybrids in agriculture has enhanced global food production and agriculture's contribution to Canada's economy

Key Idea: Examine the causes, effects and possible treatments of human genetic disease.(Science Consortium)

Objective		Resource
1.K	Describe briefly the cause, effects, possible solutions, and treatments for one or more genetic diseases : Down's syndrome, haemophilia, Klinefelter's syndrome, Turner's syndrome, Huntington's disease, muscular dystrophy, Tay-Sachs disease, and cystic fibrosis	p 223-7 p 231
2.A	Develop an appreciation of and curiosity about current research and theories concerning the nature, transmission, modification, and expression of genetic information	
3.Ap	Understand that many human and other forms of life have benefitted from improved recognition and treatment of genetic disease	

4.So Realize that the application of genetic engineering in the development of new organisms and the possibility of applications in eugenics holds great promise, but also leads to difficult moral and ethical problems that will need to be resolved

Evaluation;

*	library research project	30
*	electron micrograph exercise	5
*	model building exercise	10
*	quizzes 2 @ 10	20
*	unit test	70
		135

Ministry Guidelines

At least 30% of the term mark for this unit is to be based on students'

a) interpretation of micrographs and work with molecular models

b) library projects

Unit 6 The Theory of Evolution

Curriculum Emphasis: "Nature-of-science" emphasis

Rationale: This unit presents an excellent opportunity to discuss the differences between hypotheses, theories and beliefs. It doesn't make sense to disbelieve or believe in evolution, Hypotheses and theories are not beliefs. They are testable assertions. The changing nature of scientific theories can also be discussed.

Key Idea: Discuss the historical development of the theory of biological evolution. Describe the lines of evidence which support and explain the theory. Examine the nature of scientific theory.

Objective	Resource
1.S Discuss the theory of evolution using the library and other sources of information to obtain relevant information from various areas of biology	
2.S Abstract information from reading selections on evolutionary theory and identify the main ideas, the argument sequence, and the author's point of view	
3.K Describe briefly how Charles's Darwin gathered evidence and developed his ideas. Include reference to Erasmus, Darwin, Malthus, Lyell and the voyage of the HMS Beagle	p 20-24

4.K State and explain the Darwin/Wallace theory of natural selection p 20-24

5.K Compare Darwin's theory of the origin of species with that proposed by Lamarck

6.K Use the theory of natural selection as an example, differentiate between empirical facts and theory and describe the purpose, origin and development of scientific theories giving examples of their usefulness and limitations

7.Ap State how mechanisms of speciation may assist in the development of new varieties of domestic plants and animals

8.K Compare Darwin's thinking on the progression of the development of species with the hypothesis of "punctuated equilibrium" as proposed by S.J.Gould p 341

9.K Name and briefly describe the lines of evidence from areas of biology which support and are explained by the theory of evolution eg. evidence from paleontology comparative anatomy (homologous and analogous structures), embryology, comparative biochemistry genetics, selective breeding, and geographical distribution of species p 24-27 p 313-25

10.K Explain why Darwin was unable to account for

the mechanism of inheritance of traits in his theory

11.A Appreciate the development and explanatory value of the Neo-Darwinian theory of biological evolution

12.F Understand the difference between a belief and p 27-8
A a scientific theory, and that one does not believe or disbelieve in a theory about evolution

13.F Appreciate that evolutionary theory neither p 27-8
A refutes nor confirms the positions taken by many religions - it does not address these issues

14.A Develop a curiosity about the natural mechanisms that are explained by means of the theory of biological evolution and the usefulness and limitations of the theory

16.ApUnderstand the theory of biological evolution can be used to illustrate some of the characteristics of the nature of science

17.A Appreciate the differences between the origin, development, and nature of scientific theories and other non-scientific modes of explanation, eg. religious and metaphysical perspectives

18.ApUnderstand that the theory of evolution is used to postulate ancestral links between species

19.SoRealize that explanations for the origin of species have been the subject of considerable debate over the years

20.SoRealize the debate over the theory of evolution has been highlighted, and has encouraged people to distinguish between scientific, religious and metaphysical arguments and explanations

21.SoRealize that scientific theories such as the theory of evolution can have a profound effect on the guiding concepts of a society

Key Idea: Describe the natural mechanisms of biological evolution. Include the factors which alter genetic equilibrium of populations. Develop a working concept of how speciation occurs.(Science Consortium, 1988)

Objective		Resource
1.K	Explain with reference to the gene pool of a population why the theory of evolution applies to populations of organisms and not to individuals	p 305-09
2.K	State the Hardy-Weinberg law and explain its significance in terms of evolutionary theory	p 308
3.K	Explain the concept od adaptation by describing an example such as the development in bacteria of resistance to antibiotics	p 313-16

4.	Describe 3 or more of the mechanisms which can lead tc genetic variation in a population, eg. mutation, natural selection, genetic drift, gene flow(migration) and population increase and decrease	p 309-13
5.S	Design using beads or suitable materials models of a population genotype to show the effect of factors which alter the genetic equilibrium of a population	
6.K	Explain both the morphological and biological concept of a species, and explain why it is difficult to give a rigorous definition of a species that fits all occasions	p 330
7.K	State the relationship between genetic variation and speciation and postulate how new species can result eg. geographical isolation,polyploidy, and introgression	p 329-341 p 354
8.K	Describe the possible origin of Darwin's finches, or some other groups of related species, in terms of initially reduced selection pressure, increased genetic variation, isolation, reuniting of species, competition, and increased selection pressure	p 340 41
9.K	Compare speciation with convergent evolution	p 322-24

Evaluation

*	model exercise demonstrating factors affecting gene pool	20
*	3 labs reports investigating different lines of evidence for evolution	30
*	continuous and discontinuous variation lab	10
*	quizzes 2 @ 10	20
*	unit test	70
		150

Ministry Guidelines

At least 30% of the term mark for this unit is to be based on students'

a) design and manipulation of models

b) reports on evidence for evolution

c) other investigations or reports

Unit 7 Ecology

Curriculum Emphasis: "Environmental-ethic" emphasis

Rationale: This is a very important unit. We must take care that we don't leave the students with a "doom and gloom" feeling. Most of us resist change that requires personal sacrifice. Our role is to present the students with information and the wherewithal to make there own moral and ethical decisions. It will be difficult for students in prosperous Canada to plan for the long-term benefit as a result of short-term sacrifice. The Brundland Report has presented the concept of sustainable management. We must help our students see themselves as an integral part of the ecosystem and the biosphere.

Key Idea: Describe the meaning of the term ecology and explain related concepts.

Objective		Resource
1.K	Describe the meaning of the term ecology and explain the following ecological concepts:	p 391-400
	food web, trophic levels, biome, ecosystem	p 406-16
	community, population, niche, succession,	
	symbiotic relationship	
2.S	Measure environmental factors and interpret the data obtained in terms of the effects of such factors on populations of organisms	
3.A	Develop a commitment to establish their own informed personal environmental ethic	

4.K	Compare and explain the fluctuations (including such factors as carrying capacity, fecundity, competition, and predation) in a population of wild plant, wild animal and microorganism	p 391-400
5.Ap	Understand that the study of ecology enhances our ability to effectively facilitate the population growth of endangered species	

Key Idea: Explain the concept of the cycling of matter in the biosphere.

Objective		Resource
1.K	Explain the concept of the cycling of matter in the biosphere and briefly describe the carbon, oxygen,nitrogen, phosphorous, and water biogeochemical cycles	p 420-24

Key Idea: Describe the flow of energy through an ecosystem and account for the biomass at each of the trophic levels. Also, included are the concepts of net production and the first and second laws of thermodynamics.

Objective		Resource
1.K	Describe including the concepts of net production and the first and second laws of thermodynamics, the flow of energy through an ecosystem and account for the	p 424-26

biomass at each of the trophic levels in an ecosystem.

2.K Compare biogeochemical cycles and the flow of energy through the biosphere.

3.K Compare the use of energy by humans in North America with humans in developing countries and by non-human organisms p 447

Key Idea: The human population and its changes over the last few thousand years are described as well as the resulting stress on the biosphere.

Objective	Resource
1.K Describe and account for the changes in the human population over the last few thousand years including the concept of exponential growth	p 445-48
2.Ap Understand that research in ecology has increased our understanding of the effects and uniqueness of human intervention in the biosphere and has made it possible to consider steps to correct or reduce adverse impacts of human activity on the environment	
3.A Develop an appreciation for the conflicting interests and concerns of those involved with commercial enterprises that can have a negative impact on the environment and those dedicated	

to preserving that environment

4.A Develop a commitment to make informed rather than emotional decisions about social issues associated with environmental problems

5.Ap Understand that the knowledge of ecology makes it possible to develop an informed personal environmental ethic and to take responsibility for appropriate actions in the environment

6.So Realize that many ecological problems will be solved by informed and committed citizens acting through local organizations and government agencies to influence and regulate the activities of industry and other groups that have environmental impact

7.So Realize that society will need to support ongoing ecological research, pollution and natural resources management, and environmental programs, if the deterioration of the environment is to be brought under control

8.A Develop an responsible attitude towards the effect of our actions that directly or indirectly affect the environment

9.S Analyze and evaluate data and arguments concerning local and world ecological issues

10.A Develop an appreciation of the unique nature of the ecology of the human population in the

biosphere

Evaluation

*	field study of a local environmental problem	30
*	critical analysis of a media article or scientific report	10
*	analysis of demographic data and predictions	15
*	quizzes 2 @ 10	20
*	unit test	65
		140

Ministry Guidelines

At least 30% of the mark for this unit should be based on students'

a) measurement and interpretation of data

b) analysis of environmental phenomena

Unit 8 Optionally Designed Unit - Independent Research Project

Curriculum Emphasis: "Skill-development" emphasis

Rationale: This unit is designed to develop the student's ability to research independently. This includes: identifying a meaningful and appropriate question, collecting and organizing information and data, drawing logical conclusions, and communicating effectively. It will encourage students to appreciate the value of accepting a challenge and carrying a task through to completion.

Objectives	Resources
1.F Formulate a hypothesis and use logical arguments	
2.F Make responsible decisions	
3.F Develop enquiry skills	
4.F Plan and systematically approach problem-solving situations	
5.F Develop skill in reporting in both written and oral formats	
6.F Develop self-discipline	
7.F Develop skills in recording data in chart graph, and tabular formats	
8.F Read and utilize scientific literature	
9.F Develop skill in designing experiments	
10.F Develop skill in operating within a fixed timetable	

11.F Develop the skill of accurate and detailed record keeping and efficiency of information storage and retrieval

12.F Develop skills of analysis of data and improvement of experimental design as a result

13.F Realize the importance of basic research to life style and technology

14.F Encourage value, honesty, and responsibility in all aspects of scientific research

Evaluation

*	periodic checks of progress of IRP (journal)	10
*	Journal (final copy)	15
*	Formal Report	50
*	Interview with teacher	10
*	Science fair judges average	25
		110

NB. This mark will weigh 10% of the final course mark.

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32. Selma Wasserman and Meguido Zola, "Promoting Thinking in Your Classroom".

Appendix 1

Ministry of Education Project Team

Jack Bell (co-manager)

Laurier Bradley (co-manager)

Richard Rancourt (co-manager)

Geraldine Connelly (project co-ordinator)

Donald Garratt (project co-ordinator)

David Gregory (project co-ordinator)

John Pettit (project co-ordinator)

Thomas Donovan, Metropolitan Toronto Separate School Board

Usha Finucane, Board of Education for the City of Toronto

Bob Hartley, Lakehead Board of Education

Douglas Jolley, Eastern Regional Office, Ministry of Education

Penny McLeod, Board of Education for the City of North York

James McTavish, Western Ontario Regional Office, Ministry of Education

Brenda Molloy, Frontenac County Board of Education

Jan Thor, Board of Education for the City of York

Laurent Tregonning, Sudbury Board of Education

Glen Wiley, Lennox and Addington County Board of Education

Appendix 2

The Aims of the Science Curriculum

The goals of education may be realized in part through learning experiences based on the aims of the science curriculum. Such aims are focussed on developing in students an ability to manage their own lives, an acceptable attitude towards the world of work, an understanding of the nature of science, and some degree of scientific literacy.

Students will acquire the following attitudes, skills, and knowledge, which constitute the aims of the science curriculum.

1. **an understanding of the processes of science**

   These processes include identifying a problem, hypothesizing, observing, classifying, measuring, communicating, inferring, formulating theories and models, gathering data, experimenting, analyzing, concluding, explaining, and generalizing. Inherent in science are basic assumptions such as cause and effect, predictability, objectivity and other characteristics attributed to the nature of science. Students must realize that science is limited by its methods and assumptions and that its theories are subject to change. Nevertheless, science provides an organized explanation of natural phenomena.

2. **skills that are essential for participation in scientific work and technology**

The "scientific method", based on empirical findings and logical reasoning, plays a vital role not only in science but also in technology and science education. Those engaged in science activities must possess facility with language, computational ability, inquiry skills, manual dexterity, receptive attitudes and social sensitivity. If students are to develop such qualities, their science courses must provide opportunities for them to communicate and calculate, to engage in investigative activities, to interact with nature and the technological world, and to grapple with societal issues.

3. **facility in problem solving through science**

Students must be given opportunities to use scientific information, concepts, and processes to formulate arguments; to solve problems, both qualitative and quantitative; and to reach conclusions. They should also develop the ability to apply personal and societal values to the process of decision making, particularly at the interface between science and society.

4. **the basic knowledge needed to function in and contribute to a scientific and technological world**

Through science education, students should assimilate basic factual information and understand concepts and conceptual networks related to scientific process and skills. That is, they are expected to achieve a degree of scientific literacy which will allow them to:

- display curiosity about and enjoyment of scientific phenomena in the world around them
- appreciate science as it applies to personal life management
- enter employment with a suitable background in the fundamentals of science
- pursue further studies in science
- explore local and global science-related issues
- adapt to technological changes
- interpret scientific features in newspapers, magazines, journals, and books, and on television

5. **respect for the environment and a commitment to the wise use of resources**

The science program should enable students to develop an environmental ethic that incorporates:

- an empathy with nature and its complex interactions
- a respect for living things

- a consideration of the effects of actions on the environment
- an understanding of the needs and desires of human beings and how these influence environmental decisions

6. **an understanding of the nature of science as a human endeavour**

Science depends on people working together and sharing information, not only on the knowledge that is produced but also on the processes of inquiry. This dual aspect of the nature of science must be made apparent to students. Further, they are to be given opportunities to understand the relationships between science and society in such areas as economics, consumerism, history, politics, law, sports, and the arts.

7. **an appreciation of technology as the application of scientific knowledge and principles**

Students are to realize that many of the benefits of science are derived through technology. Students should become familiar with local, national, and international examples of the interaction between science and technology. Such examples should highlight career opportunities.

8. **an ability to locate and retrieve scientific information**

It is important that students learn to utilize various sources of scientific information such as textbooks, handbooks, journals, periodicals, reference materials, video and auditory resources, the media and computers. While students need to assimilate such knowledge, it is also essential that they learn how to learn on their own and how to find and organize scientific information when required. Because of the increasing role of computers in science, students should learn how to operate them and understand their potential in scientific work.

9. **an awareness of the career possibilities in the field of science and technology**

A large number of careers now require familiarity with the knowledge and processes of science, and this number will increase as many traditional jobs are replaced by high-technology equipment. Female as well as male students should be encouraged to enjoy science and consider the possibilities of careers in science and technology.

10. **an awareness of how the knowledge of science enhances personal life management**

Useful applications of science abound in the lives of students. An understanding of nutrition and health, medicine and safety, plants and animals, the environment and natural resources, chemical reactions and energy transfer, properties of matter and radiation, atoms and space, measures and dimensions, and appliances and machines will help students enrich and manage their own lives at school and in the years beyond.

11. a sensitivity about science and its influence on societal issues and values

Students need to be informed about and to begin to develop considerate and constructive values related to issues that will be raised throughout the science program. Such issues include population growth, origins and futures, respect for life, sexuality, food and famine, drug abuse, biological/chemical/nuclear destruction, hazardous wastes, depletion of resources, environmental control, space exploration, and scientific research.

Appendix 3

Halton Board of Education Goals

We strive for students to achieve to the best of their ability, the knowledge, skills and attitudes necessary to pursue useful and happy lives in an increasingly complex and changing world. Our staff assists students to undertake activities which will:

- foster enjoyment of learning
- develop the knowledge and skills of communication, mathematics, social science, science, arts, and modern technology
- encourage independent and interdependent learning
- develop effective problem solving and decision making skills
- enhance physical fitness, health and environmental awareness
- promote understanding and appreciation of the rights and responsibilities of a citizen of Canada within the global community
- develop respect for individual differences, needs, rights and the property of others
- promote a sense of worth and emotional well-being

Acton High School Goals

1. Belief: Everyone has the potential for growth and learning and has the freedom and responsibility to develop that potential.

Goals: -to foster self discipline and self-reliance

-to provide a learning atmosphere which respects individual differences

-to empower individuals to pursue their own growth

2. Belief: People strive for fulfillment of emotional, social, physical, intellectual, aesthetic and ethical needs

Goals: -to respond to the needs for growth in ourselves and others

-to encourage balance in lifestyle

3. Belief: A positive view of oneself is essential to realize one's potential

Goals: -to foster a positive self-concept

-to recognize achievement in all ares of life

4. Belief: Formal education provides a variety of significant opportunities for everyone to grow and learn

Goals: -to recognize the value and communicate the benefits of formal education

-to develop the attitudes, knowledge, processes and skills necessary for learning

-to provide a variety of significant and challenging program opportunities

-to employ alternative methods of delivering

program

-to develop the knowledge, attitudes, work habits and skills that will promote satisfaction and success in the world of work

-to encourage an appropriate balance in all school-supported program and activities

5. Belief: Growth and learning are lifelong processes.

Goals: -to promote the value of ongoing education

-to stimulate the enjoyment of learning

-to develop the ability to adapt to change

-to encourage interaction among those of different generations

-to respond to the learning needs of the community

6. Belief: A caring, co-operative, supportive and positive climate enhances learning.

Goals: -to develop a co-operative and inviting learning environment

-to foster positive relationships

-to encourage a caring and supportive school community

7. Belief: Respect for the physical environment, human dignity and cultural diversity is essential for the growth of society.

Goals: -to develop respect and a sense of responsibility for the physical environment

-to promote respect for an individual's

dignity and cultural background

-to develop an appreciation of one's own family, school and community

-to encourage responsible social behaviour at the various levels of interaction

Appendix 4

Teaching Through Modality Strengths

Visual Learners

- books with pictures
- subject related puzzles or games
- allow to explain using a diagram or chart
- use films, videos, film strips, slides, TV
- allow these students to design/prepare the bulletin board
- encourage projects that involve collage and posters
- have students create own crosswords
- encourage illustrated essays, scrapbooks, sketchbooks
- try to use concrete materials: maps, globes, artifacts, models, photos
- packaged computer programs

Kinesthetic Learners

- try to use concrete materials
- encourage some body movement in class by using mock trials, word games, role playing, pantomime, charades, group assignments
- use of the community for field trips, interviews, questionnaires
- encourage examples from real life experience, particularly those involving dance, sports
- use subject related games and puzzles, kits
- allow these students to help you with equipment,

materials, demonstrations

Auditory Learners

- when using blackboards, say it as you write it
- allow time for discussion
- have students talk through their ideas, answers, solutions
- encourage the use of songs, music, poetry in class
- allow time for verbal learners through debates, wordgames, charades, tutorials, seminars, group assignments
- use a variety of audio media: films, records, tapes and videos
- encourage data collection using verbal/auditory strategies; interview, questionnaire, survey