The Biology Curriculum for Senior High Schools in Manitoba

by
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THE BIOLOGY CURRICULUM FOR SENIOR HIGH SCHOOLS IN MANITOBA

BY

PAUL D. CUTHBERT

A Practicum submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements of the degree of

MASTER OF EDUCATION

Abstract

This practicum involved the development of the conceptual framework, curriculum design, introductory material, and field validation curriculum implementation document for the new Biology 30S (grade 11) course in Manitoba. The study examined recent science curriculum reform movements, trends in biology curriculum design, and recent theories of learning as they apply to science education.

The new Biology 30S curriculum was designed to provide teachers with a more comprehensive and usable document for implementation at the classroom level. Learning outcomes are presented in a way that prescribe what the student will know and be able to do as a result of completing a particular learning activity. The suggested instructional strategies allow the student to become actively involved in the learning process through activities such as laboratory investigations, journal writing, concept mapping, cooperative learning, modeling, research, and debates. More emphasis is also placed on the development of science process skills, critical and creative thinking skills, communication skills, and science-technology-society connections.

Development of the curriculum materials occurred in the context of a pre-selected provincial committee consisting of senior biology teachers, university professors, community college biology instructors, and science curriculum consultants. Materials were reviewed and approved by all committee members prior to the release of the field validation version of Biology 30S to pilot schools in the summer of 1995.

Training sessions for pilot teachers occurred during the first semester of the 1995-96 school year. Feedback concerning field testing of the new curriculum was collected from these teachers during this time. Subsequent recommendations for revisions to the curriculum have been made with the intention of implementing these changes prior to phase 2 field validation scheduled for the 1996-97 school year.

Acknowledgments

I would like to express my sincere gratitude and appreciation to the members of the Examining Committee: Dr. Art Stinner, Dr. Ed Byard, and particularly, my advisor Dr. Harvey Williams for their assistance and guidance in the development and completion of this practicum. I would also like to thank the members of the Biology 30S/40S Curriculum Development Committee and the administration of the Program Development Branch of Manitoba Education and Training for their cooperation, collaboration and support during the development of this document.

I would especially like to thank my wife Rosanna, and daughters Brittany and Alexandria for their patience, support and encouragement during the completion of this project.

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Chapter One

Introduction

Public opinion has, historically, had great impact on educational reform. At no time was this more evident than the rush to modify science curricula in the wake of the Sputnik launch in 1957. Over three decades later, similar curriculum reform movements in science education are emerging. However, in this instance, reform is occurring primarily as a result of poor student performance on national and international assessments.

Recent reports by organizations such as the *Science Council of Canada* (SCC), the *American Association for the Advancement of Science* (AAAS), the *National Research Council* (NRC), and the *Third International Mathematics and Science Study* (TIMSS) assert without citing evidence that most high school science graduates do not have a good understanding of the basic concepts and principles of science. More importantly, they claim that students cannot apply these concepts and principles to real world contexts. These organizations all support reform in science education with the goal of producing individuals who are scientifically literate.

The *Council of Ministers of Education of Canada* (CMEC) have accepted the proposition that there is a need for reform in science education and in response, have recently agreed to form a *Pan-Canadian Science Project*. The goal of this project is to develop common Canadian K-12 science curriculum outcomes and standards by the fall of 1997. According to the criteria outlined in the *Student Achievement Indicators Program: Science Assessment Framework and Criteria* (CMEC, 1994), it appears that *Pan-Canadian* science development will be grounded in standards documents such as the TIMSS *Curriculum Frameworks for Mathematics and Science* (1993), the AAAS

Benchmarks for Scientific Literacy (1993), and the NRC's *National Science Education Standards* (1994).

In Manitoba, significant curriculum revision has been prescribed in the department of Education and Training's recently released reform document entitled *Renewing Education: New Directions, The Action Plan* (1995). This document has designated the senior 3 and senior 4 science program for revision over the 1994-95 and 1995-96 school years. As a result, committees of professional educators have been appointed to design new curricula in biology, chemistry, and physics for field validation testing in the 1995-96 and 1996-97 school years.

Although science curriculum revision in Manitoba is being driven primarily by public perception that the current curriculum is not preparing our students adequately, current research in learning theory suggests that revision is needed from a pedagogical perspective. Recent studies in science education assert that meaningful learning only occurs when students are actively involved in the learning process, making connections between what is being learned with what is already known. The memorization of thousands of unrelated facts and algorithms does not result in meaningful learning (Driver, 1989; Gunstone, 1988; Solomon, 1992; Yager, 1992). A summary of teacher comments in the *Manitoba Science Assessment* (1990) reveals that Manitoba's science curricula are so content "heavy" that most teachers almost exclusively utilize didactic teaching methods such as lecture and demonstration in order to "cover" the curriculum.

The senior science curricula in Manitoba have not been revised since the early 1980's. Many scientific advancements have occurred since these documents were released, especially in the area of biotechnology. Many of these scientific advancements raised a number of important social issues, making curriculum revision necessary on this

basis alone. The challenge to curriculum development committees is to produce science curricula which are congruent with recent research on the goals of science education and curriculum design, effective in teaching and learning, and meet government criteria concerning curriculum design and standards.

Purpose

The purpose of this practicum is to:

1. Develop a conceptual framework, curriculum design, and introductory material for the new senior biology program in Manitoba
2. Develop a Biology 30S (Senior 3) curriculum implementation document for field validation testing in the 1995-96 school year
3. Make recommendations for revision of the Biology 30S course based upon feedback from pilot teachers.

Limitations

A number of limiting factors will influence the nature and design of this practicum. These are described as follows.

1. *Renewing Education: New Directions, The Action Plan*

This document states that all curricula must contain specific learning outcomes which describe the knowledge and skills that students are expected to demonstrate upon completion of a course of study. These learning outcomes will incorporate the four foundation skill areas of literacy and communication, problem solving, human relations, and technology. The new biology curriculum must conform to these specifications if it is to be approved for release.

2. *The Pan-Canadian Science Project*

The education ministers of all provinces and territories (with the exception of Quebec) have agreed to develop a common curriculum framework for K-12 science education by the Spring of 1997. Initial meetings between representatives from provincial ministries occurred in the fall of 1995. It is anticipated that development will follow the mathematics model developed in the context of the *Western Protocol for Collaboration in Basic Education*. Development in mathematics is near completion and to date has been grounded in standards documents such as *Curriculum and Evaluation Standards for School Mathematics* produced by the *National Council of Teachers of Mathematics* (NCTM, 1989), *Benchmarks for Scientific Literacy* (AAAS, 1994) and *Curriculum Frameworks for Mathematics and Science* (TIMSS, 1993).

Science curriculum framework development is expected to be guided by the above documents as well as the *SAIP Science Assessment Framework and Criteria* (CMEC, 1994) and the *National Science Education Standards* (NRC, 1994). Any provincial curriculum development which occurs must be congruent with these documents.

3. *The Biology 30S/40S Curriculum Development Committee.*

The curriculum development committee was responsible for developing the scope and sequence of the new biology program. They were also responsible for approving the learning outcomes, instructional strategies, the assessment and evaluation strategies, and learning resources written for inclusion in the curriculum document. This curriculum will be limited to the goals and objectives defined by this committee.

Significance of the Practicum

This practicum/curriculum document will provide a foundation for the new senior biology program for the province of Manitoba. In addition, it will prescribe what students should know and be able to do after completing the senior 3 biology (30S) course. Since Biology 30S will be one of the first curricula developed for the new senior science program in Manitoba, it will provide a model for further science curriculum development in the province and will serve as a working document for the *Pan Canadian Science Project.*

Chapter Two

Literature Review

The following literature review is organized into three sections. The first section examines science curriculum reform, the second section reviews current biology curriculum design, and the third section focuses on learning theory and science education.

Science Curriculum Reform

Science curricula developed prior to the 1950's gave considerable attention to the application of science to technology and the students' everyday life. However, the 1950's were dominated by the Cold War and competition between East and West. Science and technology were central to this struggle and governments felt pressured to producing more scientists and engineers. As a result, school science curriculum was re-designed to emphasize theoretical science and science for science's sake, with very little emphasis on scientific applications and technology as instructional topics (Anderson, 1992). The goals of science education in the 1960's were characterized by an emphasis on processes and techniques designed to produce scientists.

By the mid 1970's, public support for science and science education seemed to be at it's lowest point since the 1950's. Science curriculum reform efforts were viewed critically by experts and representatives of the public as most educators continued to view the goal of science education as preparing students for further study in science. In 1977, a major research effort sponsored by the NSTA and AAAS and known as *Project Synthesis* was established. This effort identified four basic goals of science education (Harms, 1977):

1. *Science for meeting personal needs.*

   Science education should prepare individuals to use science for improving their own lives and for coping with an increasingly technological world.

2. *Science for resolving current societal issues.*

   Science education should produce informed citizens prepared to deal responsibly with science-related societal issues.

3. *Science for assisting with career choices.*

   Science education should give all an awareness of the nature and scope of the wide variety of science and technology related careers open to students of varying aptitudes and interests.

4. *Science for preparing for further study.*

   Science education should provide students with a firm foundation from which they may pursue progressively higher levels of study.

Yager (1988) reported that Gallup surveys conducted in 1980, 1984, and 1986 revealed public agreement with these goals, with an even greater perceived importance for the first three goals. These surveys were conducted in fifteen different communities and were representative of service clubs and community groups such as Parent-Teacher Associations. Despite these results, the majority of science curricula continued to be designed almost exclusively for the goal of preparation for further study in science.

More recently, the poor showing of North American students on science and mathematics assessments has resulted in national science curriculum reform movements. Organizations such as the SCC, AAAS, NSTA, and TIMSS have recently produced extensive reports on science education and propose changes to science education. All of these reports state that the goal of science education should be to produce a

scientifically literate citizen. In fact, *Project 2061: Science for all Americans*, states that scientific literacy, which embraces science, mathematics and technology, should be the central goal of education (AAAS, 1989). The TIMSS asserts that there is a global recognition in the belief that scientific literacy and economic productivity are inextricably linked. Higher levels of achievement in mathematics and science are of fundamental importance to the technological development and modernization of all countries (TIMSS, 1993).

While there appears to be general agreement around the importance of scientific literacy, there appears to be no consensus around the definition of scientific literacy. The definition offered by the AAAS is frequently quoted, most notably by the SCC and CMEC. According to the AAAS (1990),

> The scientifically literate person is one who is aware that science, mathematics, and technology are inter-dependent human enterprises with strengths and limitations, and uses scientific knowledge and scientific ways of thinking for individual and social purposes.

This definition, while quoted extensively in the most of the science education reform reports, does not define what is required in terms of science curriculum reform. The AAAS has recently released the second phase of the *Project 2061* series entitled *Benchmarks for Scientific Literacy*. This document outlines what students should know or be able to do at certain levels. It states:

> If we want students to learn science, mathematics, and technology well, we must radically reduce the sheer amount of material now being covered. The overstuffed curriculum places a premium on the ability to

> commit terms, algorithms, and generalizations to short-term memory and impedes the acquisition of understanding. The effective teaching of science must be based on learning principles that derive from systematic research and from well tested craft experience. Moreover, teaching related to scientific literacy needs to be consistent with the spirit and character of scientific inquiry and with scientific values (AAAS, 1993).

In 1994, the NRC, NSTA and the *National Science Foundation* (NSF) and released the *National Science Education Standards* . This document suggests:

> The "less is more" model should be developed in achieving scientific literacy. This simply means that we should not teach every topic in the text. It is far more effective to teach fewer topics and teach them with more depth and hands-on activities, to allow for reflection, analysis, knowledge and excitement of discovery to develop and reach full impact (NRC, 1994).

In summary, there appear to a number of points of commonality in these reform movements. These are as follows:

1. The goal of science education should be to produce scientifically literate citizens.
2. In order to achieve scientific literacy, the amount of content in science curriculum should be reduced.
3. Students should become more actively involved in the learning process by emphasizing more hands-on activities and scientific inquiry techniques.

It should be noted that most reformers are quick to indicate that reform does not occur by simply introducing a new program, it emerges when new goals are stated, new

teaching strategies are used, and new modes of assessment are created. These issues will be addressed in the next two sections.

Biology Curriculum Design

Educators have debated for years about the kinds of knowledge and skills a student should gain from a senior biology program. According to Leonard (1991) and Wright (1992), over the last three decades, these discussions have been primarily content oriented. For example, should the program emphasize cell biology, ecology, anatomy and physiology, evolutionary change or biodiversity?

Manitoba's present biology curriculum emphasizes descriptive content. The *Manitoba Science Assessment* (1990) revealed that the Biology 30S curriculum is so overloaded with content that most biology teachers do not finish the core topics in the course. Teachers surveyed indicated that they utilize didactic teaching techniques such as lecture and demonstration more than 80% of the time in order to "cover" the content which is present. As a result, test scores on the 1990 curriculum assessment test were viewed as disappointing by the assessment branch of Manitoba Education and Training. Even though the students did reasonably well on multiple choice items, their performance on written response items was judged to be unsatisfactory, especially where students were asked to link ideas together and relate them to general processes like homeostasis. This suggests that students were simply memorizing the material and did not have a good understanding of the basic concepts and principles.

Many of the biology programs of the late 1950's and early 1960's, such as *Biological Science Curriculum Study* (BSCS), emphasized science process skills, science-technology-society (STS) connections, and a thematic approach to biology. In

more recent biology programs, Costenson and Lawson (1986) have emphasized the development of thinking and science process skills. McInerney(1986) emphasizes the relationship between basic biology concepts and technology and society.

In 1987, the NSTA commissioned the *Search for Excellence in Biology Teaching Task Force* to review previous attempts at defining excellence and develop new criteria for a program of excellence in biology. The task force worked for more than two years to develop the *Criteria for Excellence in Biology Teaching*. The criteria were based on the belief that biology should be taught as a two-fold holistic curriculum that examines science as a process and interrelates that knowledge to the biosphere, society, and the student. As reported by Wright & Power (1990), the task force identified the following four goals for exemplary biology programs.

The Biology curriculum should:

1. Address the present and future needs and interactions of the biosphere, society and the individual.
2. Encourage students to experience, understand and appreciate the dynamics of natural systems as a first step toward understanding and appreciating how human activity has affected these systems.
3. Organize around a sociological and technological focus for the application of basic and fundamental concepts and principles of the biosphere.
4. Pursue the development of creative and critical thinking skills applicable to the decision making process.

In 1988, the *National Association of Biology Teachers* (NABT) *Teaching Standards Committee* developed recommendations for a minimum core curriculum in senior biology. The idea was not to dictate a specific curriculum for the year but to

suggest some minimum experiences that all students should have. The committee determined that most curricula were driven by textbooks and that instruction was not consistent with recent research in learning theory. As a result of their research, the committee recommended the following design criteria for biology curriculum:

1. More emphasis on ecological issues.
2. Much less lecture and more student-centred activities.
3. Less emphasis on memorizing factual knowledge at the expense of learning process skills and concepts.
4. More active learning on the part of the student.
5. A minimum of 1/3 of instructional time be spent on laboratory or field work(Leonard, 1991).
6. More opportunity for integrating issues and concepts in science, technology and society.

Another national study entitled *Fulfilling the Promise: Biology Education in Our Nation's Schools* (NRC, 1990) reinforces the movement to reduce content and memorization of factual knowledge. It gives a specific example of a difference in the amount of detail that students should be expected to retain. According to the Council, "basic scientific literacy implies knowing that the chief function of living cells is assembling protein molecules according to instructions coded in DNA molecules, but does not imply knowing the terms "ribosome" or "deoxyribonucleic acid" or knowing what messenger RNA is and how it relates to DNA."

The results and recommendations of these studies are consistent with the recommendations presented in *Project 2061* as discussed earlier. The AAAS recognizes the importance of environmental issues facing society today and strongly supports a

greater emphasis on ecology. The AAAS also makes recommendations as to the topics of biology that should be most emphasized in a senior biology program: diversity of life, heredity, cells, interdependence of life, flow of matter and energy, evolution of life, and the human organism (including human identity, life cycle, basic functions, learning, physical and mental health).

In summary, a number of areas of consistency are evident among these recommendations on biology curriculum reform. Moreover, they are similar in nature to those concerning science education in general as discussed in the previous section. They can be summarized as follows:

1. The amount of content covered needs to reduced. Less memorization of facts.
2. Less emphasis on lecture. More emphasis on active learning.
3. Less reliance on textbooks as curricula.
4. Development of critical thinking, problem solving and science process skills.
5. More emphasis on ecological issues and science - technology - society connections.
6. More emphasis on how biology relates to the student's everyday life.

The largest discrepancy among the recommendations for biology curriculum design appears to be in the content areas to be covered. The science of biology contains immense amounts of information and the information base is increasing at an exponential rate. For this reason, many branches of biological science which may become the focus of curriculum. Accordingly, what content to teach is among the most difficult issues to resolve in the development of a new high school biology program. There appears to be a more general consensus concerning how biology should be taught.

The next section of the literature review examines research on teaching and learning in science.

Learning Theory and Science Education

Through the past quarter century, science education has been primarily influenced by behavioral and developmental psychology. The behavioral perspective builds on theories focusing on overt human behavior and regards the human mind essentially as a black box. This school characterizes learning in terms of permanent changes in observable behavior and specifies instructional objectives in behavioral terms (Champagne & Kopfer, 1991). Most existing science curricula are stated in terms of behavioral objectives.

More recently, developmental psychology has come to influence the structure and content of current science curricula. Developmental psychologists argue that there is a relationship between what a student is capable of learning and the level of the student's cognitive development. Piaget's theory of cognitive development posits an invariant sequence of stages: pre-operational, concrete operational, and formal. Some science curricula, which are truly spiral in nature, are designed on the premise that students must progress from the concrete operational to the formal level of reasoning.

In the early 1970's, research in science education began to focus on the conceptual models that lie behind students' reasoning in particular science domains. Methods such as concept mapping were developed to probe learners' knowledge structures. Two decades later, there is extensive literature that indicates that children come to their classes with conceptions that may differ substantially from the ideas being taught and that these preconceptions influence further learning and that they are resistant to change (Driver, 1989). This theory, also known as constructivism, has its roots in developmental psychology.

The *Constructivist Model* is based on the claim that knowledge must be

constructed by each learner and is dependent upon the student's existing knowledge or preconceptions (Driver, 1988). Constructivists believe that even the best students may not learn from didactic teaching. They believe that personally constructed explanations are far more powerful than any of those given by teachers and seemingly "learned" by students. This has led reformers across the curriculum to look anew at constructivism (von Glasersfeld, 1992). Constructivists advocate that teachers:

1. Seek out and use student questions and ideas to design lessons and whole instructional units;
2. Accept and encourage student initiation of ideas;
3. Promote student leadership, collaboration, location of information, and taking actions as a result of the learning process;
4. Use student thinking, experiences, and interests to drive lessons(even if this means altering teacher plans);
5. Encourage the use of alternative sources for information from both written materials experts;
6. Use open-ended questions and encourage students to elaborate on their questions and responses;
7. Encourage students to suggest causes for events and situations and encourage them to predict consequences;
8. Encourage students to test their own ideas, i.e., answer their questions, their guesses as to causes, and their predictions of certain consequences;
9. Seek out student ideas before presenting teacher ideas and before studying ideas from textbooks or other sources;
10. Encourage students to challenge each other conceptualizations and ideas;
11. Use cooperative learning strategies that emphasize collaboration, respect individuality, and use division of labour tactics;
12. Allow adequate time for reflection and analysis;
13. Respect and use all ideas that students generate; and
14. Encourage self-analysis, collection of real evidence to support ideas, and reformulation of ideas in light of new experiences and evidence.

Constructivist theory is consistent in many ways with Piagetian theory. For example, both constructivists and Piagetians would agree that a child actively constructs his or her own meanings through encounters with new experiences (Gunstone, 1988). In

addition, both theories would support the idea that learning is highly dependent upon the context in which it occurs. However, constructivists see no limit in the ability of a learner to learn anything at any age so long as that learner can be persuaded to discard their misconceptions. This assertion is in sharp contrast to Piagetian theory which states that certain scientific concepts should only be introduced at the appropriate stage of cognitive development. Moreover, Piagetian theory has emphasized the personal construction of knowledge through individual interaction with the physical environment, whereas constructivism emphasizes the social processes involved in knowledge construction (Solomon, 1987).

The cognitive science perspective, which has its roots in artificial intelligence and information theory, has also changed our conceptions of science learning and teaching (Champagne & Kopfer, 1991). Cognitive science builds its theories on models of cognitive processes and the contents and structural organization of human memory. It states that the capacity of the human memory plays a significant role in information processing, thinking and problem solving. Cognitive researchers believe that it is possible to develop practical strategies for teachers to use for achieving higher order learning, developing skills to improve retention, and enhancing understanding (Hurd, 1991). For example, cognitive scientists claim that the working memory can hold only six or seven items at one time. Thus, science teachers must consider how many items are presented at any one time. The cognitive scientists hope to close the gap between theory and research but they have yet to develop an overarching learning theory.

Most science educators support the notion that the way science is taught is equally as important as what is taught. However, there continues to be much debate around constructivist versus Piagetian theories and now cognitive science theories.

Recent science curriculum reform movements such as *Project 2061* and the TIMSS *Curriculum Frameworks for Mathematics and Science* do not explicitly support a particular learning theory, although constructivist theory is implicit to the strategies being supported by these efforts. There is evidence of support however, for all the above theories in these reform movements.

According to Kyle (1991), recent research syntheses have demonstrated the effectiveness of the hands-on, inquiry oriented science curricula developed during the 1960's and early 1970's. Kyle sites evidence that shows that students in such courses had enhanced attitudes towards science and scientists, enhanced higher-level intellectual skills such as critical thinking, analytical thinking, problem solving, creativity and process skills as well as a better understanding of scientific concepts. Inquiry oriented science courses also enhanced student performance in language arts, mathematics, social studies skills, and communication skills.

This research finding is used to support the recommendations of the AAAS in *Project 2061* (1989), the NRC/NSTA in *National Science Education Standards* , the CMEC in *Science Assessment Framework and Criteria* and TIMSS in *Curriculum Frameworks for Mathematics and Science* . These reports all assert that in order to understand science as a way of thinking and doing, as well as a body of knowledge, students must have some experience with the kinds of thought and action that are typical of science and are consistent with the nature of scientific inquiry. Collectively they suggest the following principles:

- engage students actively
- concentrate on the collection and use of evidence
- provide historical perspectives
- insist on clear expression

- use a team approach
- do not separate knowing from finding out
- welcome curiosity
- reward creativity
- encourage a spirit of healthy questioning
- avoid dogmatism
- promote aesthetic responses
- build on success
- provide abundant experience in using tools
- support the roles of girls and minorities in science
- emphasize group learning
- de-emphasize the memorization of technical vocabulary

These principles can be incorporated into many instructional strategies. Inquiry laboratory activities, cooperative learning strategies, research activities, and journal writing are a few of the instructional strategies which are advocated by the more recent curriculum movements in science education.

Summary of the Review of the Literature

The recent trends and research results relating to science/biology education presented above will inform the biology curriculum committee's deliberations as they plan this curriculum. The committee will attempt to reduce the pressure felt by biology teachers to "cover" the amount of content in the existing curriculum. Unless this problem is resolved, it will only worsen as the base knowledge in biology continues to increase geometrically. Some content expectations need to be traded off for high quality instruction in science processes and skill development, for the development of general principles or themes, and for developing the relationship to the real world.

Finally, the committee recognizes the need to change the way biology has

traditionally been taught in Manitoba. Much more time and materials need to be made available for hands-on active learning for biology. We need to address the important concepts and issues and allow students the opportunity to make connections to their existing conceptual frameworks by pursuing topics which are relevant to them.

As explained earlier, there are many external factors which will shape the formation of this new curriculum. My intention is that the information presented here will be considered during the development process.

Chapter Three

Methodology

The Manitoba Education and Training Senior Biology Program

The provincial senior biology program currently consists of four courses at the Senior 3 and Senior 4 level. These courses are designated as Biology 30S, Biology 30G, Biology 40S, and Biology 40G. The current "G" level courses are "general" in nature and are designed for students who do not wish to pursue biology at the post-secondary level. Most students who enroll in these courses do so to obtain a mandatory science credit at the Senior 3 or Senior 4 level. The current "S" level courses are "specialized" in nature and are designed for students who intend to pursue biology at the post-secondary level.

Renewing Education: New Directions, The Action Plan released by Manitoba Education and Training early in 1995 states that as of the 1996-97 school year, the mandatory science credit currently required at Senior 3 or Senior 4 level will be eliminated. Students will now be required to choose from a list of *Compulsory Complementary* courses at the Senior 3 and Senior 4 level. Therefore, a student will be able to graduate from high school without obtaining a science credit at Senior 3 or Senior 4. As a result of these new guidelines, it has been decided by the Department of Education and Training that the "G" level courses will be phased out of the Senior 3 and Senior 4 program.

The mandate of the current Manitoba Education and Training Biology Curriculum Committee is to develop only one biology course for each of the Senior 3 and Senior 4 levels. These courses will be designated as "S" or "specialized" and will

need to serve the needs of all students interested in pursuing biology at the high school level.

The Development Model

This practicum (curriculum) will be developed in the context of the Manitoba Education and Training Biology 30S/40S Curriculum Committee. The committee is composed of educators from the province of Manitoba, including high school biology teachers, university professors of education and biology, community college instructors in biology, and science curriculum consultants.

As the principal writer for this new biology curriculum, I will attempt to ground the document on the most recent research in science education as described in the previous chapter. The curriculum committee will assist in and approve the development of the conceptual framework, introductory material(instructional philosophy, goals, etc.), learning outcomes, instructional strategies, assessment strategies and learning resources presented. The material developed will be evaluated throughout the writing process through the distribution of materials to all committee members. The committee will meet on a regular basis to make recommendations for changes, additions or deletions to that material. Once the committee is satisfied with the material, it will be translated into a curriculum implementation document which will be released to the field validation schools in the summer of 1995.

Program Evaluation and Revision

The Biology 30S curriculum will be field tested in selected Manitoba high schools in the 1995-96 school year. Pilot teachers will be required to provide their evaluation of the curriculum at various stages of implementation. The pilot teachers will

receive an initial training session in August of 1995 to orient them to the new curriculum. Subsequent training/feedback sessions will be scheduled throughout the field validation period.

It is expected that information from the pilot test sites will be analyzed and appropriate modifications will be made to the curriculum for phase 2 of the field validation process, scheduled for the 1996-97 school year. As final modifications are being made to the 30S curriculum, the development of the 40S curriculum will be nearing completion. The Biology 40S curriculum will follow the similar field validation procedures as the Biology 30S. Biology 40S field validation will occur over the 1996-97 school year, with phase 1 in the first semester and phase 2 in the second semester.

Upon completion of the field validation process, the 30S and 40S courses will undergo a congruency analysis with the *Pan-Canadian* curriculum framework. If necessary, appropriate revisions will be made in the spring of 1997. Full implementation of both the Biology 30S and Biology 40S courses is scheduled for the 1997-98 school year.

Scope of the Practicum

Development of the new biology 30S/40S program will require three years for full implementation. This practicum will involve the development of the conceptual framework and introductory material to the Biology 30S/40S program, the Biology 30S curriculum implementation document, and recommendations for revision and further development based upon feedback from Biology 30S pilot teachers. The entire process will require approximately 15 months to complete.

Summary of the Development Process

The following summarizes the development process which occurred between September, 1994 and July, 1995.

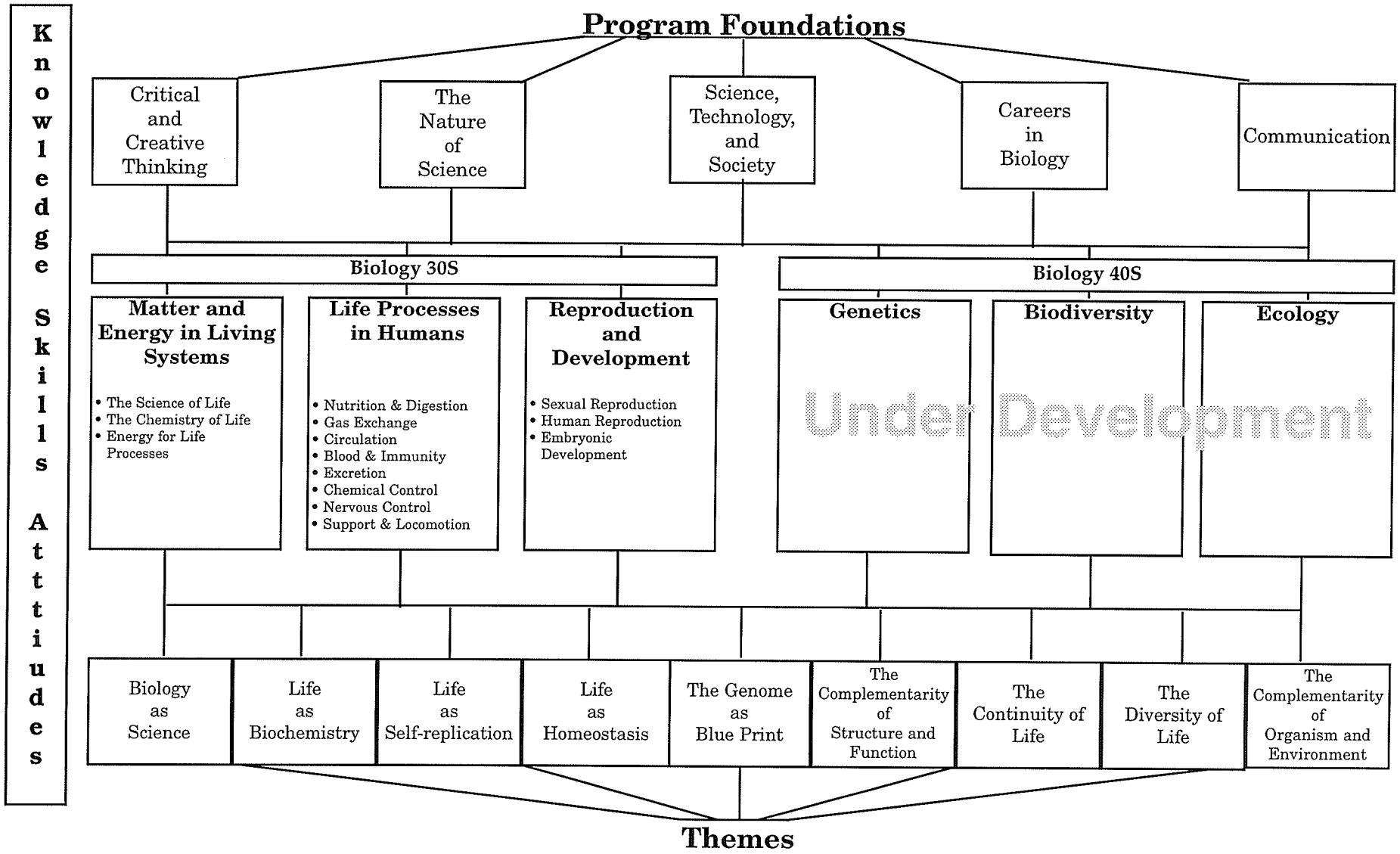
Development on the new Senior 3 and 4 biology program began in September of 1994. At this time, the new Science 20S (grade 10) course was beginning the first phase of its field validation. Four of the committee members of the 30S/40S biology committee served on the Science 20S committee. The new Science 20S course consists of equal components of biology, physics, and chemistry. After consultation with other biology teachers and the *Biology Teachers Organization of Manitoba*, the committee agreed that the biology component of the new 20S course should consist of *Cell Biology* and *Cancer*. *Cell Biology* was a component of the existing Biology 30S course.

During the initial biology curriculum committee meetings, much discussion occurred around the focus and goals of the new biology program. A congruency analysis was made of other biology curricula across the country. I presented articles summarizing curriculum reform movements in biology to the committee. From these documents and further discussion, I developed a conceptual framework (see page 28), rationale, instructional philosophy, goals, and scope and sequence for the 30S/40S program. These documents were distributed to committee members, revised and tentatively approved. They would eventually provide the foundation for further development work.

In October, 1994, a "bear-pit" session sponsored by the *Biology Teachers Organization of Manitoba* was held at the *Special Area Group (SAG)* conference. A panel of biology educators and an audience of biology teachers discussed the development of the new biology curriculum. There were conflicting viewpoints expressed in relation to the "breadth vs depth" issue, although general consensus did

Conceptual Framework

Biology 30S/40S Curriculum



emerge related to a number of issues. All agreed that the new biology program needed to have more of an ecological focus, especially at the grade 12 level. It was also agreed that students need to develop better communication, problem solving and critical thinking skills. There needed to be more emphasis on interdisciplinary connections and more time allocated to laboratory/field work. There was a general consensus that the existing curriculum was too "content" heavy. This fact made it very difficult to pursue interesting extension topics or allow students to study topics which interested them. There was also concern expressed related to the fact that the universities do not require biology as a pre-requisite to their science programs. This fact, in conjunction with the lack of flexibility in timetables at the grade 11 and 12 level was perceived to be contributing to decreases in enrollments in biology courses at the high school level.

The curriculum meeting held subsequent to the SAG conference resulted in the decision to focus the grade 11 (30S) course on Human Systems and Homeostasis and focus the grade 12 (40S) course on Genetics, Biodiversity, and Environmental Studies. It was decided that committee members would work in groups and focus on the development of learning outcomes in their respective content areas.

At this point in the development process, there had been very little guidance from the Department of Education and Training regarding the actual structure of the curriculum. The only clear message the committee received was that the curriculum could not be "linked" to any one textbook and that learning outcomes must specifically state what the student should know or be able to do. Thus, as principal writer for the curriculum, I drafted a curriculum design which included a four-column format and three sample units for the committee to review. This format included *Prescribed Learning Outcomes, Suggested Instructional Strategies, Suggested Assessment*

Activities, and Suggested Learning Resources. After considerable discussion, the committee approved the suggested format. This format has now been adopted as the new format for all curriculum implementation documents released from the Department of Education and Training. Further discussion ensued around the specificity of the learning outcomes and the nature of the instructional strategies presented in the three sample units.

An attempt was made to integrate some differentiated instructional strategies into the curriculum. These strategies include journal writing, concept mapping, model building, cooperative learning, laboratory investigations, research activities, and discussion/debate. The nature of these strategies were also incorporated into the learning outcomes. This was a non-traditional approach to curriculum design in science education in Manitoba and initially was not well accepted by some committee members. However, after lengthy discussion and reference to recent research regarding science curriculum design and learning theory, it was eventually approved and accepted by all committee members.

Once the curriculum design was accepted, we could move forward in developing specific outcomes and strategies related to the topics in each of the courses. It was decided as a group that we would focus exclusively on the development of the 30S course in order to have it ready for the spring of 1995. The unit structure for the 30S course was proposed, discussed in detail, and finalized. The course would consist of twelve units, the first three consisting of introductory material relating to the study of biology, biochemistry, and energy for life processes. The remaining nine units would focus on human systems. Each committee member agreed to work on one unit each while I agreed to work on the remaining four units. The development process continued

following this model. However, it soon became apparent that different committee members had different writing styles. Therefore, I agreed to "re-work" all of the units so that there was consistency, connection and flow throughout the course.

Finally, decisions needed to be made regarding the issue of learning resources. The committee received instructions from the Department of Education to make linkages to more than one textbook and to ensure that all schools could complete the curriculum with existing resources. After reviewing the new text resources available from publishers, the committee decided to introduce two new text resources and cross reference the three most common text resources already existing in the field. This would give schools enough flexibility to implement the new course according to the resources available to them.

A section in the resource column in the curriculum guide was left open for multimedia integration. A new *Curriculum/Multimedia Integration* program was expected to be implemented in the fall of 1995. The staff would have the task of cross referencing appropriate multimedia resources to the new curriculum outcomes and modifying the existing instructional strategies and assessment strategies as they relate to the multimedia integration.

After hundreds of hours of work on the part of the committee and myself, the field validation version of Biology 30S was released to the field in the summer of 1995. This document is enclosed in the following chapter.

Chapter Four

SENIOR 3 BIOLOGY (30S)

Phase 1 Pilot Curriculum

July 1995

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Preface

The development of this curriculum document is the direct result of an extensive review process, and reflects the input of the various partners in the educational process, including parents, educators, post-secondary representatives, and members of business and professional organizations.

In June 1990, the Minister of Education and Training released ***Answering the Challenge: Strategies for Success in Manitoba High Schools***. This document provided background for future development of Senior Years curriculum, student assessment, evaluation, and reporting. ***Renewing Education: New Directions, A Blueprint for Action***(July 1994) and ***Renewing Education: New Directions, The Action Plan***(January 1995) put forth a plan to extend the process of educational renewal.

Each of these documents address the gap between what is currently in the curriculum, and what today's Senior Years graduates need to know and be able to do in order to lead meaningful and productive lives.

The Science Steering Committee for Kindergarten - Senior 4, the Biology 30S Curriculum Committee, and Program Development Branch have strived to narrow this gap by producing a Senior 3 Biology (30S) curriculum that is relevant to the needs and interests of Manitoba students.

The reader will notice many changes in the design of this curriculum document. In particular:

- the curriculum has been designed to foster development of the four foundation skill areas: literacy and communication, problem-solving, human relations, and technology;
- outcomes are very specific in terms of the knowledge, skills, and behaviors that students are expected to demonstrate as a result of their learning;
- the curriculum is driven by these outcomes and not by a text book. Although a number of print and non-print resources are listed as resources, no single text covers the entire course. It is expected that teachers will construct the course according to the resources available to them and the particular needs of their students.
- the curriculum is supported by the *Senior Years Science Teacher Resource Manual* (1995) which has been designed to provide teachers with practical information to assist them as they implement the new science curriculum in their classroom.

The successful teaching of science depends primarily on the abilities, commitment, and initiative of teachers as well as on the learning resources available to them. This curriculum document, as one of the resources available to teachers, is intended to assist teachers in developing courses that meet the needs of their students, the school, and community. Thus, as a key organizer for science courses, this curriculum document is an essential component in the teaching of science.

Contents

Part I : Science Education

A. Trends in Science Education

While there is no universal agreement on the goals of science education, a consensus seems to be emerging among science educators. Much of the current research and discussion has focused around the areas of 1) scientific literacy, 2) learning theory, and 3) curriculum design and implementation.

1. Scientific Literacy

A national survey conducted in 1989 revealed that the level of science literacy among adult Canadians is surprisingly low. The survey also revealed that many Canadians do not have a good understanding of the basic principles of science and technology. Moreover, Canadian society did not appear to foster positive values related to scientific awareness and skills.

Science educators agree that society can no longer can we concentrate on educating only an elite cadre of future scientists and engineers, but, rather, science education must focus on all students, including those largely forgotten previously - women and minorities. The *Science Council of Canada*(1984) as well as the *American Association for the Advancement of Science*(1989) recommends:

> **Our fundamental premise is that the schools do not need to be asked to teach more and more content, but rather to focus on what is essential to scientific literacy and to teach it more effectively.**

The *Science Council of Canada*(1984) as well as *Project Synthesis*(1989), developed by the *National Science Teachers Association* (NSTA) and the *American Association for the Advancement of Science* (AAAS), both reinforce this premise by recommending four basic goals of science education:

1. Science for meeting personal needs.
Science education should prepare individuals to use science for improving their own lives and for coping with an increasingly technological world.

2. Science for resolving current societal issues.
Science education should produce informed citizens prepared to deal responsibly with science-related societal issues.

3. Science for assisting with career choices.
Science education should give all an awareness of the nature and scope of a wide . . . variety of science and technology related careers open to students of varying aptitudes and interests.

4. Science for preparing for further study.
Science education should provide students with a firm foundation from which they . . may pursue progressively higher levels of study.

These goals provide four bases for designing and evaluating curricula. Unfortunately, previous science curricula emphasized the last goal almost to the exclusion of the other three. Science education should allow students who are likely to pursue science academically as well as professionally to acquire the knowledge appropriate for their needs.

According to the AAAS, the primary goal of science education should be **scientific literacy** (*Benchmarks for Science Literacy*, 1993).

> the scientifically literate person is one who is aware that science, mathematics, and technology are inter-dependent human enterprises with strengths and limitations, and uses scientific knowledge and scientific ways of thinking for individual and social purposes.

It is difficult to give a definition of a scientifically literate person but the following description is typical and acceptable, and serves well as a working definition:

The scientifically literate person:

- **has knowledge of the major concepts, principles, laws, and theories of science and applies them in appropriate ways;**
- **uses the processes of science in solving problems, making decisions, and in other suitable ways;**
- **understands the nature of science and the scientific enterprise;**
- **understands the partnership of science and technology and its interaction with society;**
- **has developed science-related skills that enable him or her to function effectively in careers, leisure activities, and other roles; and**
- **has developed interests that will lead to a richer and more satisfying life and one that will include science and life-long learning.**

2. Learning Theory

A consensus among science educators is emerging that science education should be concerned with:

A. Learning science	constructing and developing conceptual and theoretical knowledge.
B. Learning about science	constructing and developing an understanding of the nature and the methods of science, and awareness of the complex interactions between science and society.
C. Doing science	engaging in and developing expertise in scientific inquiry, experiments, and problem solving.

These concerns are mutually reinforcing, and require that the science curriculum include investigative tasks sensitive to the relationship between knowledge about things and knowledge about how to do things.

Science educators also generally accept a **constructivist model** of learning in which:

- **learning is dependent on the preconceptions that the learner brings to the educational experience.**
- **learning is highly dependent on the context in which it occurs.**
- **each learner must construct his or her own meaning.**

However, the constructivist approach must be blended with what Piaget had to say in his stage theory about cognitive development, especially about the difficulty of going from the concrete operational to the formal level of reasoning. Piagetian ideas are very relevant for us because we know that Senior 3 and 4 students still have a tendency to function as concrete operational thinkers. **Our approach in this curriculum is to move these students towards the formal operational stage.**

For example, let us consider the teaching of electrostatics and current electricity: Electrostatics is often taught straight from a textbook, sometimes with no more than a demonstration by the teacher. In presenting the topic, the teacher often pays attention to students' experiences and "theories" only by briefly posing a few questions that may involve only one or two students responding. Students take notes, copy definitions of charge and voltage and memorize the model that is supposed to "explain" such phenomena as induction and charging by contact. Students then answer the problem situations described in the text. Even if they do well on a test, they tend to forget the definitions quickly, the model and the reasoning that was involved in explaining examples of charging by contact and induction. They certainly will have very little understanding of the connection between static and current electricity.

This curriculum proposes a different approach, one in which students actively explore natural phenomena, under the guidance of the teacher, constructing a succession of new meanings until they arrive at one that is scientifically acceptable. Students would first build their own equipment , such as an electroscope and use this instrument in testing for what the electrostatic model predicts. Later, in the electricity unit they "discover" the relationship between current, voltage, and resistance in the context of an investigation, before Ohm's law is spelled out to them for memorization. This approach is constructed from both Piaget's description of the passage from concrete operational to formal learning and current understandings of the nature of science knowledge, science processes, and skills.

SCIENCE KNOWLEDGE

Science educators generally agree with philosophers of science that science knowledge is socially constructed by scientists. The construction of this science knowledge is a dynamic phenomenon within a research program based on methodological rules. The accepted knowledge and theories are negotiated within a community of scientists by a complex interplay of theoretical argument, experiment, science policies, societal pressures, and personal opinion. Science progresses only if successive theories solve more problems than their predecessors.

As researchers seek to expand their understanding of how the world works, conceptual knowledge is utilized to drive science processes such as observation, classification, experimentation, hypothesizing etc..

SCIENCE PROCESSES

The present view of science processes is due to Gagne's work (1965). However, the idea that science processes drive science goes back at least to Pearson (1892). He advocated and described "the scientific method" that was unique to science, was specifiable, could be taught, guaranteed success and was applicable to all scientific inquiry. The Pearsonian scientific method is still with us, implicitly or explicitly enshrined in science textbooks. Both Person's scientific method and Gagne's science processes are commitments to induction. According to these views inquiry begins with observation, proceeds through the systematic organization of data, the inductive formation of inferences, and the testing of those inferences.

Based on the inductive view, instruction of conceptual knowledge should emphasize discovery; the arrangement of learning conditions so that students can infer laws and principles from interaction with the environment. Unfortunately, teaching science, or designing curricula along these lines will grossly misrepresent science and present an erroneous and simplistic view of science. Instead, science teachers must consciously try to present a picture of science where the nature of science process is dependent on the conceptual knowledge used to investigate a particular phenomenon or problem.

SKILLS

We shall look at skills in terms of, first, practical/experimental work, and then problem solving.

Practical/Experimental Work

Science educators see *doing science* other than just replicating cook-book style experiments of which textbooks are so fond. Students should be engaged in practical work, laboratory bench work and experiments. They recommend that students be engaged in *planning experiments* and *designing experiments*. These are two distinct and largely independent skills. The first is a concept-driven activity and second involves the fitting of a particular experimental design to a hypothesis. The third skill, namely *performing experiments* is what students are primarily engaged in, often by way of clear-cut cook-book style experiments, without being first engaged in the other two phases. Most science teachers would agree that practical/experimental experience must be part of science education. What they generally do not agree on is the place of experiments in scientific inquiry and the placing of these practical experiences in teaching science.

Most science teachers (and many scientists!) seem to believe that all science results from experimentation. Another damaging myth is that observation and experiment provide objective, reliable and theory-free data from which generalizations and theories arise. This view leads to a misleading understanding of the place of experiments in science. Unfortunately, many textbooks reinforce the myth that the path of science is certain and assigns a simple and clear-cut role to experiments. This is mainly accomplished by a logical reconstruction of the events leading up to the establishing of a theory. We must remember that although experiments in science are important in testing theoretical predictions they are not sufficient to provide theoretical knowledge. Rather, experiments in science must be seen as being placed in a theoretical as well as a procedural matrix.

A key point throughout science education literature is that students must have opportunities to experiment or explore in the laboratory and to participate in *designing* some experiments. Unfortunately, this element has been conspicuously absent in most schools. Laboratory programs have been limited to directed activity to verify textbook concepts or laws.

Are these skills transferable? Many science educators now believe that these skills are largely not transferable. It is suggested that perhaps what is transferable are "experimental flair" and certain attitudes and feelings of self-confidence. Certain laboratory skills may be transferable but many are not. However, there is some evidence that resulting higher-order thinking skills such as information management, critical thinking, and problem solving are transferable.

Problem Solving

John Dewey, writing in the first article of the first volume of the influential journal *Science Education* (1917), asserted that "the method of science - *problem solving through reflected thinking* - should be both the method and the valued outcome of science instruction in American schools". Science educators agree with Dewey about the importance of problem solving, but

they are far from agreeing on the method or even the terms used to describe it. Champagne and Klopfer (1982) have argued that when we speak of scientific method, scientific thinking, critical thinking, inquiry skills, and science processes, we may often be talking about problem solving.

Many middle years curricula include the four or five step "scientific method" in an effort to provide students with a strategy for attacking problems. However, the evidence (Ronning and McCurdy, 1982) from the attempt to teach such a general process suggests that junior high school students are perhaps developmentally unable to benefit from it. These researchers then suggest that a hands-on approach to the teaching of science, using tasks to arouse their curiosity, may help students to approach problems more skillfully and solve them more successfully.

Whether or not we can teach general problem solving methods is a subject of much debate. However, Lawson and Wollman's (1977) findings imply that if we wish to enhance problem-solving success, we should foster autonomy by allowing students to investigate phenomena freely. Science classrooms should provide a variety of increasingly complex and repeated experiences. Such experiences will occur most readily when students investigate real science phenomena with direct, hands-on activities.

The following is a summary of science education research and resulting recommendations for teaching problem solving. The generalizations here must be looked upon as tentative and subject to change as the research advances:

Use multiple approaches to instruction.
Multiple instructional approaches provide more opportunities for learners with different styles.

Include concrete representations and hands-on experiences.
Few adolescents operate on the formal operational level. Offer concrete manipulable experiences.

Use specific problem-solving strategies.
General strategies do not seem to be as useful as specific ones applied to concrete examples. Transfer of these skills seems to work best when the same procedures and equipment are used for new problems.

Start with familiar ideas.
Beginning with the familiar influences students' ability to identify and control variables. Too much new content all at once can result in confusion.

Provide for student-structured learning and interaction among students.
A free-choice environment promotes gains in problem-solving ability. The interaction of team and group work also appears to contribute to gains.

3. Curriculum Design and Implementation

THE DESIGNED CURRICULUM

The *Science Council of Canada* (1984), under the heading "Science Education for Tomorrow's World" reported a serious gap between what science education is *supposed* to achieve and what is *actually* achieved. The study concluded that science is mostly taught with the aim of preparing students to study more science. Little evidence was found of teaching practices or textbooks designed to promote achievement of the three other important aims (mentioned earlier).

Both the *Science Council of Canada* and the NSTA claim that the major limitation of current curricula is the use of textbooks to carry the main burden of teaching in our classrooms. Textbooks present fact after fact to be memorized and regurgitated on tests. It is also recommended that the text-teacher relationship change, that teachers plan and execute activities aimed at conceptual development and modification, and that science vocabulary be developed in context.

NSTA recommends that, as an alternative to memorization and regurgitation, a curriculum from K-12 be organized around a few topics, such as the "Big Ideas" of science. This might give a clearer focus to students and allow them to organize other topics, both scientific and non-scientific around the core, finding the interrelation of ideas. Then there would be a chance for scientific conceptions to take the place of naive conceptions as students unify their world view. For this to happen, however, the texts would have to contain fewer facts but more experimental approaches to the facts, and more evidential basis that relates observation with theory. Textbooks must be rewritten as they rarely portray the dynamic nature of science and engineering. Science in the classroom comes across as a static, completed list of results in the form of tables, theories, and laws.

THE IMPLEMENTED CURRICULUM

The teacher is the central figure who controls the implemented curriculum. Three changes must occur in the typical teacher approach:

1. **Teachers must become aware of students' early conceptions about the workings of the world.**

2. **Teachers must have an appropriate conceptual development model to guide students smoothly from early conceptions to scientific conceptions.**

3. **Teachers must become less dependent on the textbook.**

There is universal agreement among science educators about the preeminence of the textbook for teaching science on all levels. Most textbook prose focuses on academic science, with the personal goal cluster in second place, and the career and societal goal cluster far behind. Most texts allocate only a small portion of space to activities and experiments, and even then the emphasis is almost totally academic with inquiry present in very limited forms.

B. Science Education in Manitoba Schools

General Design

The general design and intent of science education in Manitoba schools has been developed by the Science Steering Committee for Kindergarten - Senior 4, with input from a variety of individual stakeholders and groups. Some of the documents reviewed included *Benchmarks for Science Literacy* (AAAS), *Third International Mathematics and Science Study* (TIMSS Group), and *Science Education in Canadian Schools* (Science Council of Canada). The following statements describe an overview for science education in Manitoba schools. This framework is expected to undergo revision in the near future to align with the results of the *Pan-Canadian Science Project* currently proposed.

Manitoba's science curriculum is designed to meet the needs of all students from basic scientific literacy to the preparation for science based careers. For our purposes, the curriculum is characterized in terms of the *knowledge, skills* and *behaviours* that define what students need to know and be able to do in each subject area at each grade level from Kindergarten-Senior 4.

KNOWLEDGE

The knowledge aspect of the curriculum consists of a breakdown of the subject matter into varying levels of specificity. The knowledge component of the curriculum:

- Is organized to display a linkage from one level to the next across the curriculum from K to Senior 4;
- Includes a representative selection of concepts from the major science disciplines that minimizes repetition and correlates with other subject areas;
- Is appropriate to the cognitive development of the student;
- Includes a variety of student experiences at different levels of thinking;
- Supports technological literacy and computer usage;
- Supports science-technology-society connections; and
- Is relevant, current, and changes as science changes.

SKILLS

The skills aspect of the curriculum describes the kinds of performance that students will be expected to demonstrate during the course of their studies. The science curriculum supports the development of foundation skills in the areas of literacy and communication; problem-solving; human relations; and technology. In particular, the science curriculum develops competence in the following areas:

- Skills, Strategies and Co-operative work habits related to good scientific practices and life-long learning;
- Scientific Processes that scientists use, such as initiating and planning; collecting and recording; organizing and communicating; analyzing (connecting, synthesizing and integrating); evaluating; negotiating, sharing, and decision making as to further action;

- Communication Skills, particularly in the areas of technical reading, technical writing , speaking and listening;
- Decision Making and Action-Taking Related to Societal Issues;
- Laboratory Skills and Activities;
- Problem-Solving Skills; and
- Independent Learning Skills where students learn to access information, evaluate and use it in new and personal ways.

BEHAVIOURS

The behaviours aspect of the curriculum depicts curricular goals that focus on the development of students' attitudes, interests, and motivations in science teaching. The science program is structured to encourage students to develop:

- An awareness of the global nature of science;
- A willingness to adapt changes in scientific theories;
- An enthusiastic positive attitude towards science;
- An awareness of the impact of science and technology in their lives;
- A recognition of the value of scientific practices;
- An attitude that supports curiosity, creativity, integrity, skepticism, and respect for evidence;
- An awareness of the impact of science in their personal development and career preparation;
- General social attitudes that assist in functioning in society including environmental sensitivity, respect for others, cooperation, and the value of excellence; and
- High regard for the importance of sustainable development strategies.

An Overview

Manitoba's science curricula are presently organized around three main themes:

Interdependency and Interaction Among Organisms (Life Science),

Changes in Matter and Energy (Physical Science)

Earth, Space, and Time (Earth and Space Science).

Each science topic is an important part of studentsí science education as they progress from K to Senior 4. Decisions regarding the topic selected, instructional approach, and level of difficulty have been made with student interests, abilities, and cognitive development in mind.

Manitoba Science Curriculum Overview

Theme	Grade K	Grade 1	Grade 2	Grade 3	Grade 4
Interdependency and Interaction Among Organisms (Life Science)	Living and Non-Living Organisms	Animals are Living Organisms --- People are Living Organisms	Living Organisms in the Environment	Life Cycles	Population Interactions --- Structures and Functions
Changes in Matter and Energy (Physical Science)	Properties of Objects	Properties of Matter	Floatation: A Property of Matter	Energy, Heat and Temperature --- Changes in Matter --- Air/Air Pressure	Electricity --- Sound
Earth, Space and Time (Earth and Space Science)	Size, Position and Time	Comparing and Measuring Events	Light and Shadows --- Measuring Time, Objects and Position	Sun, Earth and Moon	Water and Land

Manitoba Science Curriculum Overview

Theme	Grade 5	Grade 6	Grade 7	Grade 8
Interdependency and Interaction Among Organisms (Life Science)	Adaptations to the Environment	Interactions of Populations within the Environment	Microbes and Ecosystems	Cells and Organ Systems --- Plants and the Total Environment
Changes in Matter and Energy (Physical Science)	Electric Charges --- Force and Motion --- Physical and Chemical Changes	Forces and Motion --- Machines	Light --- Physical Properties and Physical Changes of Matter	Heat --- Alternative Forms of Energy --- Flight
Earth, Space and Time (Earth and Space Science)	The Changing Earth	Weather --- The Earth and the Solar System	Rocks, Minerals and Soils --- The Observable Universe	

Manitoba Science Curriculum Overview

Theme	Senior 1	Senior 2	Senior 3	Senior 4
Interdependency and Interaction Among Organisms (Life Science)	Reproduction and Heredity --- Plant and Animal Interactions	**Science 20S** Introduction to Cell Biology --- Cancer	**Under Revision**	**Under Revision**
Changes in Matter and Energy (Physical Science)	Force, Work and Motion --- Chemical Interactions	Lab Safety Elements and the Periodic Table Chem. Formula, Naming Cmpds Electrostatics Current Electricity	**Under Revision**	**Under Revision**
Earth, Space and Time (Earth and Space Science)	The Changing Earth's Crust		**Under Revision**	**Under Revision**

Detailed Scope and Sequence

In science teaching, a linkage or framework is used to present important concepts, conceptions, and principles. Rather than teach disconnected topics, science is best taught in themes (energy, force, human biology, matter, ...) in contexts that are ideally designed by teachers in collaboration with students. Science educators must ensure that periodic revisitations of these do not lead to boredom. For example, the concept of energy is taught in early years curricula. It is revisited in middle years and again in the science disciplines in senior years. As early as grade school students commit to memory that "energy is the ability to do work". Teachers must prevent students from slavishly clinging to this incomplete definition of energy throughout their high school days. Students must be provided with rich contexts and problem situations that ensure that important and fruitful concepts like energy take on new and more sophisticated, and for the students more fruitful, meaning as they progress in their study.

Many science teachers believe that concepts such as energy, force, etc. should be taught at a certain level and then assumed to be part of the scientific knowledge of the student. Repeating such concepts is deemed to be boring and not necessary. However, learning is now generally seen as an adaptive process in which the learner's conceptual schemes are progressively reconstructed in keeping with a wider range of experiences. Thus such difficult and important concepts as energy and force must be revisited on many levels of sophistication in progressively richer contexts.

The following scope and sequence charts illustrate the basic features of Manitoba's curriculum. In this design, students revisit a previously studied topic to develop a deeper and more complete understanding of the concepts involved.

Manitoba Science - Scope and Sequence by Theme and Grade

Theme	Grade K	Grade 1	Grade 2	Grade 3	Grade 4
Interdependency and Interaction Among Organisms (Life Science)	LIVING AND NON-LIVING characteristics plants as living organisms, growth needs	ANIMALS ARE LIVING ORGANISMS animal characteristics comparison of different animal properties animal care PEOPLE ARE LIVING ORGANISMS variations and comparisons among people characteristics	LIVING ORGANISMS IN THE ENVIRONMENT properties unique to six animal groups (insects, birds, mammals, amphibians, reptiles, fish) properties of deciduous trees and plant needs organisms and response to stimuli animal/plant characteristics and habitats human interactions with the environment	LIFE CYCLES complete and incomplete metamorphosis animal behaviour and instinct	POPULATION INTERACTIONS nature of a population and habitat animal interdependency, herbivores, carnivores, omnivores, and predator/prey food recycling, food chain and web population / environment interactions human interactions STRUCTURES AND FUNCTIONS cell structure and characteristics skin and skeletal structures - size, materials, strength size, shape design and materials affect a structure's strength

Manitoba Science - Scope and Sequence by Theme and Grade

Theme	Grade 5	Grade 6	Grade 7	Grade 8
Interdependency and Interaction Among Organisms (Life Science)	ADAPTATIONS TO THE ENVIRONMENT structural and behavioural adaptations (plants and animals), adaptations related to distribution, reproduction and survival	INTERACTIONS OF POPULATIONS WITHIN THE ENVIRONMENT population's needs and competition producers and consumer human dependency and interaction with environment	MICROBES AND ECOSYSTEMS ecosystems-interaction of abiotic factors micro-systems factors affecting population growth in a yeast culture microorganisms - benefits and harm	PLANTS AND THE TOTAL ENVIRONMENT energy cycle factors involved in photosynthetic process growth and soil plant respiration plant role in environment and with humans CELLS AND ORGAN SYSTEMS organization - cell to system structure and function - circulatory and respiratory systems health problems and solutions

Manitoba Science - Scope and Sequence by Theme and Grade

Theme	Senior 1	Senior 2	Senior 3	Senior 4
Interdependency and Interaction Among Organisms (Life Science)	PLANT AND ANIMAL INTERACTIONS interactions - from competition to predation energy changes in food chains to pyramids nature of succession management REPRODUCTION AND HEREDITY asexual and sexual cellular reproduction human reproductive system, structure and cycles variations in human traits genetic control and prediction	**Science 20S** INTRODUCTION TO CELL BIOLOGY germ theory of disease development of cell theory modern microscope care and use of microscope structure and function of cells differences between plant and animal cells factors that limit cell size CANCER cell division and cell differentiation biology of cancer types of cancer recent advances in cancer research/ case studies	**UNDER REVISION**	**UNDER REVISION**

Manitoba Science - Scope and Sequence by Theme and Grade

Theme	Grade K	Grade 1	Grade 2	Grade 3	Grade 4
Changes in Matter and Energy (Physical Science)	PROPERTIES OF OBJECTS senses help determine properties of objects (size, colour, shape, texture, hardness, weight) classification and identification from properties change in properties	PROPERTIES OF MATTER materials have unique properties, can identify characteristics of solids and liquids changes in solid properties (dissolved, heated) patterns and order in change	FLOATATION: A PROPERTY OF MATTER objects vary in ways they float different liquids and shape affect an object's floatation depth of a liquid has no effect designs of objects can be tested for floatation	CHANGES IN MATTER matter made of parts particles in liquids and gases separation in mixtures liquids vary in properties nature of physical change AIR AND AIR PRESSURE properties of air warm air rises air contains water vapour ENERGY, HEAT TEMPERATURE heat energy causes motion expansion and contraction temperature measurement conductors and insulators absorption - colour	SOUND sound caused by vibrations, pitch sound travel - direction, loudness sound conductivity sound pollution and control ELECTRICITY single cell circuit switch several cells circuit (one bulb) series and parallel circuit conductors, insulators and the light bulb electricity/society

Manitoba Science - Scope and Sequence by Theme and Grade

Theme	Grade 5	Grade 6	Grade 7	Grade 8
Changes in Matter and Energy (Physical Science)	PHYSICAL AND CHEMICAL CHANGES properties identify objects characteristics of physical change (shape, size, state, mixtures) chemical change characteristics ELECTRIC CHARGES static electricity - nature and production electric current -chemical production electromagnetism, applications FORCE AND MOTION unbalanced forces and motion weighing objects -balance beam and spring scale transmission of forces test of strength	FORCES AND MOTION air pressure force on an area factors affecting floatation and design of floating objects SIMPLE MACHINES effort and resistance relationships (six simple machines) lever, inclined plane and pulleys relationships (quantitative) complex machines contain two or more simple machines	PHYSICAL CHANGES OF MATTER changes in state, water cycle molecular theory fusion, vaporization and temperature factors affecting solutions and separation properties of industrial products, testing LIGHT transformation of light energy light transmission - reflection and refraction light and colour uses of lens	HEAT heat and temperature energy transformations to heat heat transfer and applications expansion, contraction and applications alternative sources ALTERNATIVE FORMS OF ENERGY formation or production of fossil, solar, nuclear, wind, and hydro-electric energy cost-benefits of alternatives FLIGHT factors affecting lighter-than-air flight forces and controls on heavier-than-air flight design factors flight in space

Manitoba Science - Scope and Sequence by Theme and Grade

Theme	Senior 1	Senior 2	Senior 2 (cont.)	Senior 3 and 4
Changes in Matter and Energy (Physical Science)	CHEMICAL INTERACTIONS characteristics of chemical change elements, atoms, compounds and reactions conservation of matter acids and bases, characteristics and tests household chemistry and safety FORCE - WORK AND MOTION unbalanced forces, gravity quantitative relationships within simple machines (inclined plane lever, pulley) mechanical advantage, work and efficiency friction effect on efficiency	**Science 20S** LABORATORY SAFETY safe and unsafe practices WHMIS / use of MSDS ELEMENTS AND THE PERIODIC TABLE element names atomic theory Mendeleevian periodic table modern periodic table CHEMICAL FORMULAS, COMPOUNDS, NAMING compounds and law of definite proportions compounds, ionic and covalent polyatomic ions and compounds conserving chemical resources sustainable development, renewable and non-renewable resources, mining industry	**Science 20S** ELECTROSTATICS electric charge - protomodel electron model simple electrostatic devices CURRENT ELECTRICITY electrostatics to current electricity electric current nature and sources of potential difference electric circuits electricity in the home chemistry/biology connection	**UNDER REVISION**

Manitoba Science - Scope and Sequence by Theme and Grade

Theme	Grade K	Grade 1	Grade 2	Grade 3	Grade 4
Earth, Space and Time (Earth and Space Science)	SIZE, POSITION AND TIME size comparisons (non-standard units) reference points and position ordering of events	COMPARING AND MEASURING EVENTS regular and irregular events events in time sequence time measurement (non-standard and standard units)	MEASURING TIME, OBJECTS, AND POSITION time measurement - standard units size and distance - standard units position location measurement LIGHT AND SHADOWS light position and size, nature of shadows	SUN, EARTH AND MOON travel of light through materials light reflection sun - object shadows relative position - night and day, moon phases	WATER AND LAND erosive effects of water factors effecting erosion absorption of water into land water cycle conservation

Manitoba Science - Scope and Sequence by Theme and Grade

Theme	Grade 5	Grade 6	Grade 7	Grade 8
Earth, Space and Time (Earth and Space Science)	THE CHANGING EARTH rocks and minerals crystallization sedimentary rock formation fossil formation	THE EARTH AND THE SOLAR SYSTEM rotation and time revolution and seasons planets in the solar system technology for observation WEATHER factors affecting air movement humidity, air movement relates to cloud formation and precipitation weather and air masses prediction and technology	ROCKS, MINERALS AND SOILS igneous, sedimentary and metamorphic rocks the rock cycle testing of minerals uses of rocks and minerals nature and production of soil erosion and soil management THE OBSERVABLE UNIVERSE location using a two-coordinate system; moon characteristics, and Earth-moon interactions characteristics of sun as a star constellations, galaxies technology used to explore space	

Manitoba Science - Scope and Sequence by Theme and Grade

Theme	Senior 1	Senior 2	Senior 3	Senior 4
Earth, Space and Time (Earth and Space Science)	THE CHANGING EARTH'S CRUST alternate theories for continental structure plate tectonics theory structure and characteristics of the Earth's crust tectonic plates and volcanoes, earthquakes, mountains	**UNDER REVISION**	**UNDER REVISION**	**UNDER REVISION**

SUMMARY

The goals of science education cluster around the general mandate of educating a scientifically literate citizenry. That is to say, science education should prepare individuals to meet personal needs, to enable them to resolve current societal issues, provide them with an awareness of a wide variety of science and technology careers, and lay the foundation for continued study. In addition, this curriculum is designed around the main assumptions of constructivists' theory, namely that learners construct their own meaning, that learning is dependent on preconceptions and the context in which it occurs. In particular, this document supports both 1) that learning is an adaptive process in which the learners conceptual schemes are progressively reconstructed in keeping with a wider range experiences, and 2) Piagetian stage theory regarding cognitive development, especially about the difficulty of going from the concrete operational to the formal level of reasoning.

Science must be seen by teachers as being driven by conceptual knowledge and not by inductive experimentation. In fact, science processes are dependent on the conceptual knowledge used to investigate a particular phenomenon or problem. Laboratory work should also go beyond the conventional directed activity to "verify" textbook concepts or laws. Similarly, problem solving must go beyond memorizing algorithms for solving problems, neatly categorized by students for the purpose of regurgitation. A large portion of laboratory work and problem solving should involve situations that are often proposed by the student, that generate questions having no obvious solutions (not even to the teacher) but can be solved using only elementary concepts and methods.

Science educators are now promoting Kuhn's picture of science: pre-paradigm, normal science, revolutionary science, a valid, personal, imaginative and dynamic science. This curriculum has been designed to reflect some of this dynamism and vitality of science. We must teach students not only what we know in science but also the reasons for knowing. Aristotle said over 2000 years ago that to know a scientific fact we must not only know the fact but also know why it is considered a fact.

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Part II: The Senior 3 Biology (30S) Curriculum

Curriculum Rationale

Why Is the Study of Biology Important?

There is a basic human desire to understand one's surroundings, interpret the natural world that affects us, and learn how our body functions. The study of biology provides learners with these opportunities. In addition, the study of biology can allow for the development of an individual's abilities to reason logically and independently. Our technological society presents us with a number of social, economic and political choices. To make these difficult choices requires informed citizens who are scientifically literate and appreciate the beauty and respect the integrity of the natural world.

A senior biology program must also provide the basis for further academic work and career training for those students who wish to pursue their interests in biological science and related fields after leaving secondary school. A biology program should provide an adequate knowledge base, but more importantly should assist in the development of critical thinking, group cooperation, and communication skills through shared problem solving experiences. These interpersonal skills will be of benefit to students regardless of their later careers of life pursuits.

Finally, the senior biology courses attempt to help students understand science as a particular kind of human endeavor; one that is an important part of our culture. History demonstrates how the social and political climate influences biological research and technology, and vice versa. Science is a powerful way of thinking, learning and knowing, but its limitations must also be clearly understood. Developing an understanding of a scientific approach is an important part of every individual's general education.

What Should Be Taught?

As the depth and range of our knowledge about living things has increased, the science discipline we used to call biology has become increasingly fragmented and specialized, forming subdisciplines such as Ecology, Developmental Biology, Molecular Biology, Physiology, and Evolutionary Biology which are often, themselves, subdivided. Cross disciplines such as Biochemistry, Biophysics, and Psychobiology have further blurred the boundaries of Biology. While all of the biology related disciplines are founded on a common framework of biological theory, the differences that distinguish them are as great as the differences that distinguish physics from chemistry. Each discipline pursues its own field of inquiry with its own methods of research

The profusion and scope of biological knowledge is of such proportions that decisions must be made as to what to include and what to leave out. Accordingly the Biology 30S and 40S curriculum includes only those topics that are deemed to be of greatest relevance to students needs and interests or are prerequisites to the further study of biology. It also provides teachers with enough flexibility that they can build on the interests of their student as well as their own interests and strengths as biology teachers.

This curriculum builds on the biology background acquired in Middle Years science, Senior 1 science and Senior 2 science. Topics that were presented in earlier courses are revisited in greater depth and complexity, several new topics are introduced, and the presentation is more theoretical than in the earlier grades.

Curriculum Goals

Manitoba Education and Training, within the context of the Biology curriculum development committee, has adopted the following goals for the senior high biology curriculum:

The Biology curriculum should allow students to:

- **Master key biological concepts, principles and ideas.**
- **Master important science process skills through laboratory and field investigations.**
- **Develop an understanding and appreciation of the nature of science and methods of scientific inquiry.**
- **Develop an understanding and appreciation of the diversity of life and interrelations existing between organisms.**
- **Develop an understanding and appreciation of the relevance of biology as an integral part of their everyday lives.**
- **Develop a proficiency in critical and creative thinking and problem solving.**
- **Develop an understanding and appreciation of the place of humans in nature and the effects that humans have on their environment.**
- **Develop an understanding and appreciation of the connections between biology and other scientific and non-scientific disciplines.**
- **Develop an understanding and appreciation of the effect technology has on advancements in biological science and the resulting effects on society.**
- **Help students make informed decisions about further studies and careers in biology.**

Curriculum Foundations

In order to achieve the intended goals of Senior 3 Biology (30S), a number of curriculum foundations should be incorporated consistently by the teacher. Some suggestions have been placed within this curriculum guide to assist teachers in the integration of these foundations. However, a conscious effort must be made by teachers to introduce different instructional strategies that are designed to achieve these goals. The foundations are as follows:

Critical and Creative Thinking

Critical thinking is the use of reasoning to solve a problem, make a decision, or form an opinion. It involves collecting evidence, judging reliability, analyzing, grouping, classifying, inferring, and making value judgments. Creative thinking is the generation of novel ideas, explanations, or solutions which foster originality and independent thought. Proficiency in both of these skills is needed for successful problem solving in all subject areas and in everyday life. Teachers can foster the development of these skills by providing an environment which is supportive of student ideas and the students' use of metacognition (thinking about their own thinking).

The Nature of Science (Science as Inquiry)

The various scientific disciplines are alike in their reliance on evidence, the use of hypotheses and theories, and the kinds of logic used. Students should be made aware of this, while at the same time understand that there is no fixed set of steps that scientists always follow to lead them to scientific knowledge. Evidence is achieved through observation and measurement. In many cases, scientists will control variables to determine effects of other variables. Students must also be made aware that what is presently known or believed is subject to change at any time. Teachers must foster the development of scientific inquiry skills in students without compromising creativity.

Science, Technology and Society: Bioethics and Biotechnology

Important and controversial biological issues that affect our society should be presented in a balanced way, showing both sides of the issue. Students should be encouraged to express their own views in a discussion group. (e.g. disposal of nuclear waste). Student interest and achievement is heightened when the program of studies is enriched with contextual applications and connections to the real world. Recent information on the latest technological advances in biology should also be presented. Students should be encouraged to consider and discuss the societal or personal implications of these technological innovations. (e.g. DNA fingerprinting).

Careers in Biology

A broad range of biology related careers should be presented to students, indicating the educational and training requirements for each. Students should also be made aware of the types of problems that individuals encounter in their day to day lives in each of these careers.

Communication

Discourse in science calls for the ability to communicate and share ideas and information with fidelity and clarity and to read and listen with understanding. Students must therefore be encouraged to communicate their ideas both verbally and in written form, utilizing representations such as graphs, tables, and diagrams to enhance the presentation of information.

Curriculum Themes (Conceptual Framework)

The senior high biology program is organized around a number of unifying biological themes which emerge in varying degrees throughout every unit within the curriculum. Many of these themes emerge in all sciences and provide a means to link the conceptual organization of the various scientific disciplines. Themes are ideas and concepts encountered again and again in many contexts and various forms as one explores a coherent body of knowledge.Topics, in contrast to themes occur only once or a few times, and are often used as section or unit headings. The following are the principal themes of biology that guided the development of this curriculum:

Biology as Science

Biology as science refers to more than the body of assertions about the nature of life that we call biological knowledge. It also refers to the processes by which that knowledge is acquired and represented. In common with the other sciences, the aim of biology is not the mere accumulation of facts and generalizations: biology's ultimate aim is to explain that which observed. Moreover, biologists like other scientists, do not wander around gathering facts until they can make a general statement; their search for facts is guided by theory and conjecture. Science does not advance by formula. There is no prescribed sequence of steps to be followed that ineluctably leads to scientific knowledge.

Life as Biochemistry

The properties that distinguish living from non-living have always been the subject of speculation. Speculations which tended toward the supernatural are now often referred to collectively as "vitalism". Descarte (1596-1650) was well ahead of his time when he challenged vitalism by attempting to explain life in terms of the laws of physics and chemistry. Modern biological science assumes that life can be explained in terms of chemical and physical processes. The disciplines that focus on life at the molecular level are biochemistry and molecular biology. All the observable attributes of life are ultimately traceable back to biochemical processes.

Life as Self-replication

One of the most obvious attributes of life is that living things from viruses to humans use materials from their immediate environment to make replicas of themselves

Life as homeostasis

The two attributes common to all life are self replication and homeostasis, a term literally meaning "steady state".A nodding acquaintance with the second law of thermodynamics is required to grasp the full meaning of the term homeostasis. Thermodynamics is the branch of physics dealing with the transformation of heat to and from other forms of energy. The second of thermodynamics states that energy always flows from where it is more concentrated toward where it is less concentrated. Physicists describe the universe as "running down" as energy moves from a concentrated, relatively well-ordered state (low entropy) to a less concentrated and more disordered state (high entropy). The energy is concentrated as matter in stars. When stars like our Sun radiate their energy into empty space the energy is less concentrated and the entropy of the universe has increased. When entropy in the universe has increased as far as the laws of physics permit, the universe will have "run down". An

implication of the second law is that ordered, unconstrained, energy-containing particles become disordered. This explains why sugar (or sodium chloride) dissolves in water. The water molecules are unconstrained and interact with the sugar molecules to loosen their crystal structure. In its simplest form, life at the molecular level can be viewed as an unstable, ordered set of macromolecules that uses energy to preserve its order, the energy coming either directly or indirectly from the sun. Living systems, whether at the cellular, tissue, or organismic level are highly ordered systems in a state of dynamic equilibrium with their immediate environment.

The Genome as Blue Print

The genome is the complete set of genes carried by an organism. It carries a blue print for the replication of the organism. The organism is an expression of that genome. Modern biology views the organism as a vehicle for the transmission of the genome (The Selfish Gene, Richard Dawkins). The more successful the vehicle, the more widespread and numerous the genome. Physical and behavioral traits that appear to be self-destructive may, in fact, contribute to the proliferation of the genome. Natural selection favours genomes that produce the best vehicles. While genomes are relatively consistent in reproducing themselves, random changes (mutations) do occur from time to time resulting in new genomes. Eventually the new genomes are expressed as slightly different vehicles (variants). If the new vehicle is successful, the modified genome flourishes.

The Complementarity of Structure and Function

The structure of organs reflects their function. For example, the function of a kidney is to remove nitrogenous and other waste products from the blood. Its structure is adaptive to that purpose. The function of the wing is to support the animal in flight. It is structured accordingly.

The Continuity of Life

All existent life forms can be traced back to the earliest life on Earth. There is no evidence that new life is presently being created on Earth.

The Diversity of Life

The biosphere is a diverse environment for life and is populated by a wide diversity of life forms. The trend since the beginning of life on Earth has been toward increased diversity, but diversity has fluctuated over the eons due to natural phenomena. Our species, now the dominant life form on Earth, is having an adverse effect on the diversity of life.

The Complementarity of Organism and Environment

Organisms are finally tuned to their environment by natural selection. This theme has wide implications both for humans and for the protection of the environment.

Instructional Philosophy

How Should Biology be Taught?

Biology should be taught as a two-fold curriculum that examines science as a process and interrelates that knowledge to the biosphere, society and the student. The biology program should employ instructional strategies that include the collection and analysis of data from both laboratory and field work, the use of living organisms, group and individual instruction, a diversity of questioning techniques, a focus on current major issues and a resource based approach to learning. The program should foster critical thinking skills and promote the integration of knowledge and application of facts to real-life situations.

Biology should be taught as a way of thinking that has rules for judging the validity of answers applicable to everyday life. Science should be portrayed as intense human activity, full of trial and error, that is influenced by cultural priorities and perspectives. The myth of total objectivity that often permeates scientific dialogue also needs to be exposed. Truth should be placed in the context of something always to be sought, but we must realize that the goal can never be reached in absolute terms. Students should be encouraged to make distinctions between what is observable and testable, as well as the abstract deductions, models and themes that flow from evolving biological research and thinking.

Conceptual knowledge in biology must also be integrated with principles from other disciplines. Social, historical, and political implications must be included, with an opportunity for students to develop a facility to communicate biological ideas effectively through verbal and written expression. Finally, students should be provided with an opportunity to develop an awareness of the options available to them for careers and vocations in the biological sciences.

Ethical Issues

For many students and teachers, the study of biological concepts may lead to issues and questions that go beyond the traditional biology curriculum. For example, the technological application of biological principles in areas such as genetic engineering, human reproduction and medical technology obviously raise questions of ethics and values. Due to the fact that these questions grow out of the study of biology, they should be addressed, but it must be made clear to students that biological science only provides the background for what is hoped will be informed personal and social decisions. Teachers must handle these questions with sensitivity.

Concerns may be expressed by some students and parents because the evolutionary perspective of modern biology conflicts with personal beliefs. The individuals have a right to expect that science and the educational system will respect those beliefs. Teachers should explain to students that science is only one way of learning about life, and that other explanations have been put forth besides that of biological science. In some cases, individual teachers may choose to discuss various alternative viewpoints on these matters with their biology classes. However, because these viewpoints are not derived from the discipline of biological science, they are not part of the curriculum.

Learning Resources

The teaching of science at the Senior Years level has been largely a one textbook-centered enterprise. The use of a single textbook as the sole resource for the teaching and learning of science severely restricts the development of knowledge, skills and behaviours that are critical for today's students. Furthermore, it promotes the idea that all answers are in a textbook. This Senior 3 Biology (30S) curriculum, rather, depends on resource-based learning where textbooks are used only as one of many reference sources. Research suggests that we should provide a wide range of learning resources for structuring teaching and learning experiences including human resources, recommended textbooks, magazines, films, audio and video recordings, communication and computer technologies and other materials. While a teacher may choose to use a particular text as a primary resource, we encourage the teacher to model the use of a multitude of resources for their students.

Resources referenced by this curriculum include five suggested textbooks, two lab manuals, and other print reference material. Videotapes, videodiscs, CD-ROM's, films, internet sources and computer software will be integrated during the Phase 1 pilot.

We strongly recommend that teachers use existing resources pending results from the *Pan-Canadian Science Project* and the possibility of new resources being identified. The choice of textbook or textbooks will depend on the local situation, reading level of the students, background of the teacher, community resources, availability of other materials, etc.. A concerted effort should be made to utilize appropriate resources from a wide variety of locations. Not all curricular topics are covered by any one text and some topics could require using a reference text or outside support.

An **appendix**, located at the end of the document is provided to support this biology curriculum. Items selected for the activity guide were those not readily available in most textbooks and considered essential by the development team. This includes selected activities and information on journal writing, concept mapping, cooperative learning, and assessment and evaluation.

Additional resources expected to be available with the pilot program are the Senior Years Science Teacher Resource Manual (1995) and the Science Safety Manual (1995). Both of these documents address and update current topics of interest to science educators.

Suggested Textbooks:

Title	Author(s)	Publisher (year)	MTBB#
Nelson Biology	Ritter et al	Nelson (1993)	48248
Biology: A Systems Approach	Kormondy/Essenfeld	Addison-Wesley (1988)	48211
Biology of Ourselves	Berry/Gopaul	Wiley (1990)	48238
Biology: The Study of Life	Schraer/Stoltze	Prentice Hall (1993)	48259
BSCS: An Ecological Approach	BSCS	Prentice Hall (1992)	TBA

Using This Curriculum Document

Course Description

This curriculum, consisting of twelve units, is designed to build on what students know and are able to do as a result of their studies in Senior 1 Science (10G) and the revised Senior 2 Science (20S) course. If the former Science 20S curriculum was used, students will have missed the following units from the revised Science 20S curriculum: 1) Introduction to Cell Biology; and 2) Cancer. Teachers are asked to be sensitive to the varying backgrounds of their students and to adapt instruction as necessary. This Senior 3 Biology (30S) curriculum should provide a solid foundation for further study in Senior 4 Biology (40S). It is recommended that the units be taught sequentially, although teachers should use their discretion. There may be opportunities to achieve outcomes in different contexts to the way they are presented in this curriculum document. In all cases, however, the program foundations, themes and the and the interdisciplinary nature of science should be emphasized.

The scope of biological knowledge is of such proportions that decisions needed to be made as to what to include and what to leave out of the Senior 3 and Senior 4 Biology courses. After many hours of deliberation and consultation, a consensus agreement was reached. The Senior 3 Biology (30S) program would continue to retain a human biology focus. Accordingly, the Biology 30S curriculum includes only those topics that are deemed to be of greatest relevance to students needs and interests or are prerequisites to the further study of biology.

The Senior 3 Biology (30S) program assumes 110 hours of instructional time. It is estimated that the total time required for the teaching of new material will be 90 hours, with the balance of instructional time utilized for assessment and evaluation. Some time may need to be allocated to reviewing/reteaching material from the revised Senior 1 Science (20S) program. The unit outline for the Senior 3 Biology (30S) course is as follows:

Unit 1:	**The Science of Life**	**.5 hours**
Unit 2:	**The Chemistry of Life**	**.7 hours**
Unit 3:	**Energy for Life Processes**	**.6 hours**
Unit 4:	**Nutrition and Digestion**	**.8 hours**
Unit 5:	**Gas Exchange**	**.5 hours**
Unit 6:	**Circulation**	**.9 hours**
Unit 7:	**Blood and Immunity**	**.9 hours**
Unit 8:	**Excretion**	**.5 hours**
Unit 9:	**Chemical Control**	**.5 hours**
Unit 10:	**Nervous Control**	**.12 hours**
Unit 11:	**Support and Locomotion**	**.7 hours**
Unit 12:	**Reproduction and Development**	**.12 hours**
	TOTAL	**.90 hours**

Preparing a Lesson

The format of the curriculum document allows teachers to view the four major columns, namely *Prescribed Learning Outcomes, Suggestions for Instruction, Suggestions for Assessment,* and *Suggested Learning Resources.* The most important column for the teacher is expected to be the *Prescribed Learning Outcomes* column. These outcomes should guide the teacher to make relevant decisions as to instruction, learning resources and appropriate assessment/evaluation. The *Suggestions for Instruction* column provides possible avenues or actions for classroom presentation. *Suggestions for Assessment* outlines a number of assessment strategies beyond simple pencil and paper testing. Print materials (non-print to be developed) to support the prescribed outcomes are detailed in the final column, *Suggested Learning Resources.* It is hoped that this new format provides a useful "map" for teachers. i.e. What students are to know and be able to do, as well as some strategies and materials to help them achieve these outcomes.

In previous curriculum documents, the main outcome has been a focus on a wide variety of knowledge, i.e. a large amount of content material. This curriculum continues to be concerned with students acquiring relevant knowledge, but is equally concerned with the development of skills (context-based process skills, problem solving skills, laboratory experimental skills, critical thinking skills, independent learning skills), and with affecting a change of behaviour (operationally identifiable changes in attitude). In broad terms these outcomes should describe what we expect students to know and be able to do as a result of their studies.

Each unit begins by describing the probable *Entry Level Knowledge* of students based on previous studies using Manitoba's science curricula. Teachers are encouraged to determine student entry levels and select or develop materials to enable each student to achieve success. Many educators believe that time spent at this task has the greatest effect on student learnings.

In conclusion, this Senior 3 Biology (30S) curriculum is outcome rather than text book driven. This design empowers teachers to design appropriate learning experiences based on the nature of their students, school, and community. For some, this will be a breath of fresh air - an endorsement to teach as they have always taught or as they wanted to teach. For others, it may at first seem confusing or threatening. We encourage teachers to seek their own comfort level with the new curriculum, to share approaches and experiences with colleagues, and to use it to develop and extend student experiences and understandings in new ways.

Unit 1

The Science of Life

Overview

5 hours

Topics	Conceptual/Skill Development
1.1 **Why Study Biology?** 1 hour	• what is biology? • fields of biological science. • value of understanding basic biological principles • recognize careers in biology
1.2 **What is Life?** 2 hours	• characteristics of living things • design a new life form • major themes in biology 30S/40S program • homeostasis as a central theme
1.3 **Biology as Science** 2 hours	• application of scientific principles to the study of life • limitations of science • deductive and inductive processes in science • observations and inferences • formulating hypotheses and designing experiments. • theory, principle and operational definition

Prescribed Learning Outcomes

Topic 1.1: Why Study Biology

The student will be able to:

1.1.1 Define the term biology.

1.1.2 Describe some of the fields of biology.

1.1.3 Explain the value of understanding basic biological principles.

1.1.4 Recognize some possible career paths related to biology.

1.1.5 Demonstrate the ability to use a journal in biology.

Suggestions for Instruction

Entry Level Knowledge:
Students will have been introduced to the life sciences throughout K-Senior 1 and in the study of cell biology in Senior 2 science. Teachers should review where necessary.

1.1.1 - 1.1.5
Teacher-led Discussion/Journal Activity:
Introduce the activity of journal writing with students. Students should be encouraged to make daily entries and write down any questions they would like answered as material is presented. Emphasize the fact that journals are very important to practicing biologists. Have students answer the following questions in their journals: What is biology?, Why are they taking this course? What would they like to learn in this biology course?

Introduce the term *biology* and its Greek origin. Discuss some of the major fields of biological science with students e.g. zoology, botany, microbiology, genetics, ecology, etc.

1.1.3
Cooperative Learning Activity:
Form groups of 3 or 4 students to suggest ways in which knowing about biology could benefit them. Each group should report back to class after 10 minutes of discussion. Discuss why the study of biology is important to human existence.

1.1.3 - 1.1.4
Teacher-led Discussion/Research Activity:
Have students name some occupations related to biology. Give some other examples of occupations and ask the students whether they think a knowledge of biology would be important in that occupation, e.g. criminologist in the O.J. Simpson trial.

Have students search the classified ads for job opportunities that require knowledge of biology and post the ads on the classroom bulletin board. Students could bring in newspaper accounts of incidents where a knowledge of biology would have been helpful e.g. first aid. A "Biology in the News" bulletin board is an excellent way to motivate students.

Suggestions for Assessment

Knowledge

1.1.1 - 1.1.4
Written test/quiz

Skills and Processes

1.1.5
Journal Entries

1.1.3 - 1.1.4
Cooperative Learning Activity:
Participation in group work
Research Activity:
Oral Report
Participation in class discussion
Location of relevant ads, articles

Self-assessment

1.1.5
Journal Writing:
Stress the importance of journals in analyzing the way the student constructs their own knowledge and develops personal meaning. They are able to see how their thinking changes over time.

Suggested Learning Resources

Print

Texts

Biology: A Systems Approach
Chapter 1 - pages 1-8

Biology of Ourselves
Careers - page 37

Biology: The Study of Life
Careers - pages 16, 167, 264, 386, 403, 553, 577, 719, 807, 837

Nelson Biology
Careers - pages 97, 217, 305, 415, 565, 652

Biological Science: An Ecological Approach
Careers - pages 18, 73, 252, 357, 495, 590, 657

Activities

Journal Writing in Biology - Appendix
Cooperative Learning in Biology - Appendix

Multimedia

Topic 1.2: What is Life

The student will be able to:

1.2.1 Characterize the properties that distinguish living things from non-living things.

1.2.2 Design a new life form based upon the characteristics of living things and the environmental conditions present on a hypothetical planet.

1.2.3 Identify and describe the major themes in the biology 30S/40S program.

1.2.4 Define the term homeostasis as it relates to biological systems.

1.2.5 Discuss the importance of homeostasis as a central theme in the study of biology.

1.2.6 Demonstrate the ability to construct a concept map.

1.2.1
Teacher-led Discussion/Journal Activity:
Identify students preconceptions about life by placing several non-living objects and illustrations of living things (or some live plants and animals) on the demonstration counter and ask students to classify them as living or non-living. Next, place some dead animals or plants or parts of them on the counter and ask the class to classify them. Students should enter their responses in their journals.
Discuss or have students research and report on some early conceptions of life.

1.2.1-1.2.2
Cooperative Learning Activity:
Organize students into groups of 4 or 5 to discuss the nature of life. Have each group make a list of the properties they associate with living things. After each group has completed their list, see if all groups can reach a consensus on the criteria that define life. Once the list is complete, have each group design a new life form based upon a hypothetical planet and the properties of life they have identified. Have each group report on their ideas and justify their design (see activity guide).

1.2.3
Teacher-led Discussion:
Discuss the major themes of biology (as outlined in the introduction to the curriculum guide) with students. Stress the difference between topics and themes.

1.2.4 - 1.2.5
Teacher-led Discussion:
Define homeostasis and discuss the importance of homeostasis as a central theme in the study of biology and in particular, the 30S biology program. Use examples at the cellular level, organism level and ecosystem level.

1.2.6
Student Activity/Concept Mapping:
Introduce concept mapping with students at this time. Present the students with a number of different topic areas of biology and see if they can relate the different themes to these topic areas with the use of a concept map.

Suggestions for Assessment

Knowledge

1.2.1 - 1.2.5
Written test/quiz

Skills and Processes

1.2.2
Cooperative Learning Activity
Participation in class activity/discussion

1.2.6
Concept Mapping
Making connections with the use of concept maps. Identify student preconceptions.

Self-assessment

1.2.6
Concept Mapping
Concept mapping helps the student make abstract information more concrete and useful by visually representing relationships among concepts. A concept map can show the stages of a process, the interaction of a series of events, or present a hierarchy.

Suggested Learning Resources

Print

Texts

Biology: A Systems Approach
Chapter 1 - pages 9-18

Biology of Ourselves
Homeostasis - pages 22, 432

Biology: The Study of Life
Chapter 1 - pages 4-8

Nelson Biology
Homeostasis - page 117

Biological Science: An Ecological Approach
Homeostasis - pages 35-36, 66-74, 80-82, 445-7

Activities

Designing a New Life Form - Activity Guide
Concept Mapping - Appendix

Multimedia

Topic 1.3: Biology as Science

The student will be able to:

1.3.1 Recognize the limitations of science.

1.3.2 Distinguish between deductive and inductive processes in science.

1.3.3 Recognize the difference between observations and inferences.

1.3.4 Formulate hypotheses inductively and deductively

Entry Level Knowledge:
Students are likely to have many misconceptions about the nature of science. They will probably not understand the importance of deductive processes in science, viewing science as being essentially, if not exclusively an inductive process.

1.3.1
Discussion/Cooperative Learning Activity:
Break class up into groups of 3 or 5 and distribute a list of assertions to the groups, e.g. red is a more attractive colour than blue, chocolate tastes better than vanilla, stealing is wrong, eating meat improves your health, the digestive tract contains bacteria, mosquitoes transmit malaria, smoking causes cancer, etc.. Have the groups discuss and decide whether or not the assertions can be proven (or disproved) on scientific grounds. Report back to the class.

1.3.2
Teacher-led Discussion:
Discuss the difference between inductive (inferring of a general law from particular observations) and deductive (testing assumptions and/or theories) processes.

Cooperative Learning/Research Activity:
Break the class up into groups of 3 to 5 and have the groups research and examine historical accounts of important discoveries in biology for evidence of inductive and deductive processes. Possible historical accounts that might be used include; Robert Hooke's microscopic studies of cork (inductive), Schwann and Schleiden's development of the cell theory (inductive), William Harvey's discovery of the circulation of the blood (deductive). The first two could draw on the study of the cell in Science 20S. Groups should report back to the class.

1.3.3 - 1.3.4
Student Activity:
Have students observe an organism for a period of time and record all their observations e.g. a squirrel feeding. Be sure to distinguish between observations and interpretations (inferences). Discuss the differences between observations and inferences. Have students attempt to hypothesize based on their observations.

KNOWLEDGE
SKILLS AND PROCESSES
OTHER ASSESSMENT

1.3.1 - 1.3.2
Written test/quiz
Use hypothetical situations

1.3.1
Cooperative Learning Activity
Participation in class activity/discussion

1.3.2
Research Activity
Participation in research/report

1.3.3-1.3.4
Student Activity:
Observation skills
Formulating hypotheses

SUGGESTED LEARNING RESOURCES

PRINT

TEXTS

Biology: A Systems Approach
Chapter 1 - pages 5-6

Biology of Ourselves

Biology: The Study of Life
Chapter 1 - pages 13-14

Nelson Biology
Chapter 1 - pages 21-23

Biological Science: An Ecological Approach
Chapter 1 - pages 5-6, 16-17, 19-21

MULTIMEDIA

TOPIC 1.3: BIOLOGY AS SCIENCE
continued

The student will be able to:

1.3.5 Identify and explain the role of controls and variables in experiments.

1.3.6 Design experiments to test hypotheses.

1.3.7 Differentiate between hypothesis, theory, principle, and operational definition.

1.3.8 Apply the principles of science to the study of living things.

1.3.4-1.3.8
Teacher-led Discussion/Student Activity:
Ask students to state some generalizations related to biology. For example, they might say that cold weather in the fall makes leaves fall off trees. Write their generalizations (hypotheses) on the board or overhead and ask them what evidence they have for their generalization.

Have students design an experiment to test one of their generalizations.
Discuss the use of controls and variables in scientific experiments. Discuss research on smoking, diet, and exercise on health in terms of control and experimental groups. Differentiate between hypothesis, theory, principle, and operational definition.

Teacher-led Discussion:
Determine students' conceptions of the nature of science inquiry by exploring the experiments they have designed.

Review the history of Harvey's discovery of the circulation of the blood. Identify hypotheses that he was testing with procedures such as tying off blood vessels on live animals with which he was experimenting. This might also be a time to discuss the ethics of such vivisection.

The important point for students to gain from this work is that a theory is a scientific explanation or model that can never be finally proven but can be disproved if hypotheses deduced from it are not supported experimentally. Equally important is that students to not come away with the idea that theories are partially-proved principles.

Give students a list of emotions often attributed to animals such as fear, anger, affection, and hunger then have the students identify the behaviour they associate with those emotions as operational definitions of the emotions.

Cooperative Learning/Research Activity:
Form class into groups of 3 or 5 and have them critically examine research reports on various health threats e.g. smoking, radiation, etc..

KNOWLEDGE
SKILLS AND PROCESSES
OTHER ASSESSMENT

1.3.5 - 1.3.7
Written test/quiz
Use hypothetical situations

1.3.6
Student Activity:
Experimental Design
Critical Analysis of Research

Journal Writing

Concept Mapping

SUGGESTED LEARNING RESOURCES

PRINT

TEXTS

Biology: A Systems Approach

Biology of Ourselves

Biology: The Study of Life
Chapter 1 - pages 14-17

Nelson Biology
Chapter 1 - page 22

Biological Science: An Ecological Approach
Chapter 1 - pages 21-24

LAB ACTIVITIES
Biology: A Systems Approach Lab Manual -
Science and the Scientific Method (page 53)
Biology: The Study of Life -
A Controlled Experiment (page 28)

MULTIMEDIA

Unit 2

The Chemistry of Life

Overview

7 hours

Topics	Conceptual/Skill Development
2.1 **The Carbon Atom** 1 hour	• importance of carbon compounds in living systems • structure and bonding characteristics of carbon • building models of carbon compounds
2.2 **Carbohydrates** 1.5 hours	• role of carbohydrates in living systems • monosaccharides, disaccharides, polysaccharides • demonstrating dehydration synthesis and hydrolysis • identification of carbohydrates in the laboratory
2.3 **Lipids** 1.5 hours	• role of lipids in living systems • triglycerides, phospholipids, waxes • saturated, unsaturated, polyunsaturated fats • identification of lipids in the laboratory
2.4 **Proteins** 2 hours	• role of proteins in living systems • structure of proteins and amino acids • denaturation and coagulation of proteins • identification of proteins in the laboratory • identification of unknown food samples in the lab
2.5 **Nucleic Acids** 1 hour	• role of nucleic acids in living systems • structure of DNA and RNA • building models of nucleic acids

Prescribed Learning Outcomes

Topic 2.1: The Carbon Atom

The student will be able to:

2.1.1 Describe the importance of carbon in living systems in terms of its role in forming the backbone of all biological molecules.

2.1.2 Explain how the electron configuration (valence) of the carbon atom allow it to bond to many different types of atoms.

2.1.3 Construct models of simple carbon-based molecules illustrating the formation of single and double bonds.

Suggestions for Instruction

Entry Level Knowledge:
Students have been exposed to atomic structure and covalent bonding in Senior 2. Teachers should review where necessary.

Teacher-led Discussion/Journal Activity:
Explain to students that the chemistry of the human body greatly influences the body's homeostatic responses through different systems. Therefore, it is important that they understand fundamental biochemistry and bioenergetics before studying the remainder of the 30S/40S program. Ask students why carbon is important in the study of biology. Have them enter their responses in their journal. Attempt to eliminate incorrect preconceptions. Have students start a concept map and build on it as they work through this unit.

2.1.1-2.1.2
Emphasize to students that carbon is the single most important atom to life on Earth today. Even though cells are 70-95% water, the remainder of all cells consists of carbon based compounds. Proteins, carbohydrates, lipids, DNA and other molecules found in living systems are composed of carbon atoms bonded to one another and to atoms of other elements by way of covalent bonds. Carbon based compounds or organic compounds can be broken down within cells to release energy or linked together to form the large macromolecules essential for life. Discuss the versatility of carbon in being able to share four electrons (valence-4) in four different directions, thereby having the ability to bond with many different types and numbers of atoms.

2.1.3
Cooperative Learning Activity:
Using ball and stick or paper models, have students work in groups and build simple carbon compounds such as methane and carbon dioxide in order to demonstrate the bonding characteristics of carbon.

Suggestions for Assessment

Knowledge

2.1.1-2.1.3
Written test/Quiz
Draw/label models

Skills and Processes

2.1.3
Constructing Models
Performance evaluation
Cooperative Learning Activity
Participation in class activity/discussion

Other Assessment

Journal Writing

Concept Mapping

Cooperative Learning

Suggested Learning Resources

Print

Texts

Biology: A Systems Approach
Chapter 4 - pages 122-124

Biology of Ourselves

Biology: The Study of Life
Chapter 4 - pages 57-60

Nelson Biology
Chapter 2 - pages 51, 57

Biological Science: An Ecological Approach
pages 15, 77-78, 89-90

Multimedia

Prescribed Learning Outcomes

Topic 2.2: Carbohydrates

The student will be able to:

2.2.1 Describe the role of carbohydrates in the functioning of living systems i.e. primary source of energy.

2.2.2 List five common foods which are high in carbohydrate content.

2.2.3 Differentiate between natural sugars and artificial sweeteners.

2.2.4 Construct models of simple carbohydrate molecules and illustrate the processes of dehydration synthesis and hydrolysis.

2.2.5 Differentiate between and give examples of monosaccharides, disaccharides and polysaccharides.

2.2.6 Describe the structure and function of the polysaccharides starch,glycogen and cellulose in living systems.

2.2.7 Identify a sugar and a starch using simple laboratory tests such as the glucose strip test or Benedict's test for sugar and the Lugol's iodine test for starch.

Suggestions for Instruction

2.2.1-2.2.3
Teacher-led Discussion/Journal Activity:
Ask students what they know about carbohydrates in terms of where they come from and what they are used for in the body. Emphasize the fact that carbohydrates come from plants as a result of photosynthesis and are the primary source of energy in living systems. Discuss the importance of including carbohydrates in our diets and some examples of foods which are high in carbohydrates. Discuss artificial sweeteners as well. This could be assigned as a research activity.

2.2.4-2.2.6
Cooperative Learning Activity:
Using ball and stick or paper models, have students works in groups and construct molecules of glucose and fructose as examples of monosaccharides. These models can then be used to demonstrate dehydration synthesis during the formation of sucrose and maltose (disaccharides) Emphasize to students that almost all polymers found in the human body are formed by this process. Using these molecules, have students demonstrate hydrolysis as well (this will be important for understanding the section on digestion).
If enough glucose models are available, attempt to construct a portion of a polysaccharide such as starch, glycogen, or cellulose stressing the fact that they are composed of multiple glucose subunits with a complex branching or coiled structure. Explain to students how this structure is related to their function.

2.2.7
Teacher Demonstration/Student Activity:
Perform simple tests for sugars and starches in the laboratory such as the Benedict's test or glucose strip test for sugars and the Lugol's iodine test for starch. It is important that students learn how to use these tests as they will use them later in the unit to test foods for nutrients.
If time allows, you could demonstrate the decomposition of sucrose by adding concentrated sulfuric acid, yielding pure carbon.

Suggestions for Assessment

Knowledge

2.2.1-2.2.7
Written test/quiz
Draw/label molecules

Skills and Processes

2.2.3
Library Research
Oral/written report
2.2.4
Construct models of carbohydrates
Performance evaluation
2.2.7
Lab - Identifying Carbohydrates
Performance evaluation

Other Assessment

Journal Writing

Concept Mapping

Cooperative Learning

Suggested Learning Resources

Print

Texts

Biology: A Systems Approach
Chapter 4 - pages 128-129, 143-144

Biology of Ourselves
Chapter 7 - pages 210-215

Biology: The Study of Life
Chapter 4 - pages 57-62

Nelson Biology
Chapter 2 - pages 58-60

Biological Science: An Ecological Approach
pages 88-91, 405-406, 414-416

Lab Activities

Nelson Biology - *Identification of Carbohydrates* (page 61)
Biology of Ourselves - *Testing for Carbohydrates* (page 215-216)
Biology of Ourselves - *Sources of Carbohydrates* (page 213)

Multimedia

Prescribed Learning Outcomes

Topic 2.3: Lipids

The student will be able to:

2.3.1 Describe the role of lipids to the functioning of living systems i.e. energy storage, cell membrane structure, protective molecules.

2.3.2 List five common foods which are high in fat content.

2.3.3 Construct models of simple triglyceride molecules illustrating the differences between saturated, unsaturated and polyunsaturated fatty acids.

2.3.4 Discuss why polyunsaturated fats are less harmful to the human body than saturated fats.

2.3.5 Explain why cholesterol has become so important to health conscious consumers.

2.3.6 Differentiate between HDL's and LDL's in terms of their effects on the body.

2.3.7 Identify a lipid using a simple laboratory test such as the Sudan IV test or translucence test.

Suggestions for Instruction

2.3.1-2.3.2
Teacher-led Discussion:
Ask students about their knowledge of lipids or what are commonly known as fats. Most students will respond by saying that fats are bad for you. Accept these responses but emphasize the vital role that lipids play in the body i.e. energy storage molecules (triglycerides), structural molecules in cell membranes (phospholipids) and protective molecules (waxes). Stress that only the overconsumption of lipids is potentially dangerous to the body. Discuss common foods containing fats.

2.3.3
Cooperative Learning Activity:
Using ball and stick or paper models, have students works in groups and construct triglyceride molecules from glycerol and three fatty acids by dehydration synthesis. Make certain students construct triglycerides with saturated, unsaturated, and polyunsaturated fatty acids in their models to illustrate their differences.

2.3.4-2.3.6
Teacher-led Discussion/Cooperative Learning Activity:
Emphasize the fact that foods containing polyunsaturated fatty acids such as plant oils can be metabolized more easily by the body. Molecules such as cholesterol (HDL's and LDL's) and anabolic steroids should be discussed here as well. However, you should revisit these molecules in the context of the systems they affect. You may want to assign these topics as research activities.

2.3.7
Teacher Demonstration/Student Lab Activity:
Perform simple tests to identify lipids in the laboratory such as the Sudan IV test or translucence test.

If time allows, you could also demonstrate the extraction of lipids from meat using organic solvents.

Suggestions for Assessment

Knowledge

2.3.1-2.3.8
Written test/quiz
Draw/label molecules

Skills and Processes

2.3.1-2.3.2
Participation in class discussion
2.3.3
Construct models of lipids
Performance evaluation
2.3.4-2.3.6
Library Research/Class Discussion
Oral/written report
Participation in class discussion
2.3.7
Lab - Identifying Lipids
Performance evaluation

Other Assessment

Journal Writing

Concept Mapping

Cooperative Learning

Suggested Learning Resources

Print

Texts

Biology: A Systems Approach
Chapter 4 - pages 130-131

Biology of Ourselves
Chapter 7 - pages 216-218

Biology: The Study of Life
Chapter 4 - pages 62-64

Nelson Biology
Chapter 2 - pages 62-64

Biological Science: An Ecological Approach
pages 88-91, 405-406, 414-416

Lab Activities

Nelson Biology - *Identification of Lipids and Proteins* (page 61)
Biology of Ourselves - *Identification of Fats and Oils* (page 218)

Multimedia

Prescribed Learning Outcomes

Topic 2.4: Proteins

The student will be able to:

2.4.1 Describe the role of proteins to the functioning of living systems i.e. structural molecules, enzymes, antibodies.

2.4.2 List five common foods which are high in protein content.

2.4.3 Construct a model of a simple polypeptide molecule, illustrating the structure of an amino acid and dehydration synthesis.

2.4.4 Differentiate between a polypeptide and a protein.

2.4.5 Explain using examples, the terms denaturation and coagulation as they relate to the complex structure proteins.

2.4.6 Explain why certain amino acids must be consumed in our diets and some possible effects of a lack of amino acids in our diet.

2.4.7 Identify a protein using a simple laboratory test such as the biuret test.

2.4.8 Design and perform an experiment to analyze an unknown food substance for the presence of carbohydrates, lipids and proteins.

Suggestions for Instruction

Entry Level Knowledge:
Students will have have been introduced to the function of proteins in Senior 2. Teachers should review where necessary.

2.4.1-2.4.2
Teacher-led Discussion/Journal Activity:
Have students give their interpretations of what proteins are and why they are important in the human body. From this activity, emphasize the importance of proteins as structural molecules in cells, in tissues such as muscle, skin, nerves, hair, etc., in regulating chemical reactions in the body (enzymes), and in immunity (antibodies). Discuss common foods containing protein.

2.4.3-2.4.5
Cooperative Learning Activity:
Have students build simple polypeptide molecules from simple amino acids using ball and stick or paper models.
Emphasize that most proteins are complex molecules which have a globular or twisted structure. Using examples, explain the terms denaturation and coagulation. Denaturation and coagulation will be discussed further in the context of enzymes. Teachers could demonstrate the boiling of an egg to reinforce the concept of coagulation.

2.4.6
Teacher-led Discussion:
Emphasize the diversity of proteins possible with different combinations of amino acids. Present students with a chart. Differentiate between essential and non-essential amino acids. Discuss some possible effects of a lack of a certain amino acids in the diet.

2.4.7-2.4.8
Teacher Demonstration/Student Lab Activity:
Perform simple tests for proteins in the laboratory such as the biuret test.

Have students design and carry out an experiment where they identify unknown food substances for the presence of carbohydrates, proteins, and fats. Discuss laboratory safety and experimental design with your students.

Suggestions for Assessment

Knowledge

2.4.1-2.4.8
Written test/quiz
Label/draw models

Skills and Processes

2.4.1-2.4.2
Participation in class discussion
2.4.3
Construct models of proteins
Performance evaluation
2.4.4-2.4.7
Participation in class discussion
2.4.8
Lab - Identifying Proteins
Performance evaluation
Lab - Identifying Unknown Food Substances
Performance evaluation
Experimental Design
Lab Report

Other Assessment

Journal Writing

Concept Mapping

Cooperative Learning

Suggested Learning Resources

Print

Texts

Biology: A Systems Approach
Chapter 4 - pages 132-133

Biology of Ourselves
Chapter 7 - pages 219-222

Biology: The Study of Life
Chapter 4 - pages 64-67

Nelson Biology
Chapter 2 - pages 66-68

Biological Science: An Ecological Approach
pages 92-93, 405-406, 418-419

Lab Activities

Nelson Biology -
Identification of Lipids and Proteins (page 61)
Biology of Ourselves -
Identification of Proteins (page 221)
Biological Science: An Ecological Approach -
Biological Molecules (page 87-89)
Biology: A Systems Approach Lab Manual -
Nutrition (page 87-92)
Biology: The Study of Life - Lab Manual
Testing for Nutrients (page 31)

Multimedia

Prescribed Learning Outcomes

Topic 2.5: Nucleic Acids

The student will be able to:

2.5.1 Describe the importance of nucleic acids in the functioning of the human body i.e. genes and chromosomes.

2.5.2 Construct or illustrate and describe the general shape of a nucleic acid molecule, i.e. double helix

2.5.3 Differentiate between DNA and RNA in terms of structure and function.

Suggestions for Instruction

Entry Level Knowledge:
Students will have been introduced to nucleic acids in Senior 1 and Senior 2, but not in detail. Teachers should review where necessary.

2.5.1-2.5.3
Teacher-led Discussion/Journal Activity:
Ask students where they have heard the term nucleic acids or DNA/RNA. Have them enter their responses in their journals.
Stress to students that these complex molecules are made up of nucleic acid molecules within their cells. Nucleic acids comprise the genes and chromosomes of all cells and as such are responsible for constructing proteins.
Briefly discuss the structure of nucleic acids in that their functional units are nucleotides and the differences between them resulting from the sequencing of the nitrogen bases on the sugar-phosphate backbone. Discuss the basic differences between DNA and RNA. A more detailed study of nucleic acids will occur during the study of genetics in the 40S course.
The nitrogen base adenine also forms one of the components of ATP, discussed in the next unit.

Cooperative Learning Activity:
If models are available, have students build a model representing a portion of a DNA molecule, stressing the double helix shape and the nitrogen base arrangement on the sugar-phosphate backbone.
If time allows, you could do a demonstration or student laboratory activity showing the extraction of nucleic acids from onion, calf thymus, E. Coli, or yeast. You may wish to defer this activity to the unit on Genetics in 40S.

Teacher-led Student Activity:
Students should attempt to complete the concept map which they started at the beginning of this unit. Determine if students can make connections between the concepts introduced. Also, have students reflect on what they have entered in their journals. Have all their questions been answered? If not, it may be appropriate to attempt to answer these questions for students or provide a means by which they can be answered. Teachers should attempt to repeat this activity with students at the end of each unit in the curriculum.

Suggestions for Assessment

Knowledge

2.5.1-2.5.3
Written test/quiz
Fill in chart comparing DNA and RNA

Skills and Processes

2.5.2
Construct models of DNA/RNA

Self-Assessment

Journal Writing
Have all questions been answered?

Concept Mapping
Can they make the connections?

Cooperative Learning

Suggested Learning Resources

Print

Texts

Biology: A Systems Approach
Chapter 4 - pages 134-135

Biology of Ourselves

Biology: The Study of Life
Chapter 4 - pages 64-65

Nelson Biology
Chapter 2 - pages 70

Biological Science: An Ecological Approach
pages 89-90, 97-98

Multimedia

Unit 3

Energy for Life Processes

Overview

6 hours

Topics	Conceptual/Skill Development
3.1 **Cell Energy** 1.5 hours	• importance of energy to living systems • free energy vs chemical energy • the energy cycle in living systems (photosynthesis and cellular respiration) • exergonic and endergonic reactions
3.2 **Enzymes** 3 hours	• role of enzymes in biological reactions • measuring pH and the role of buffers in maintaining pH • identification of factors which affect enzyme activity • induced fit and lock and key theories • cofactors and coenzymes
3.3 **Energy Storage and Transformation** 1.5 hours	• role of ATP in biological reactions • structure of ATP • phosphorylation and electron transport • oxidation-reduction reactions • role of oxygen in energy production

Prescribed Learning Outcomes

Topic 3.1: Cell Energy

The student will be able to:

3.1.1 Explain in general terms why energy is required in living systems, i.e. in maintaining homeostasis, movement, etc..

3.1.2 Differentiate between free energy and chemical energy in terms of how they relate to living organisms.

3.1.3 Relate the first and second law of thermodynamics to entropy.

3.1.4 Differentiate between metabolism, catabolism and anabolism in terms of how they relate to living organisms.

3.1.5 Compare and contrast autotrophic and heterotrophic nutrition.

3.1.6 Illustrate the relationship between processes of photosynthesis and cellular respiration.

3.1.7 Differentiate between exergonic and endergonic reactions using cellular respiration and photosynthesis as examples.

3.1.8 Design a simple closed ecosystem.

Suggestions for Instruction

Entry Level Knowledge:
The energy cycle is studied in Grade 8. Teachers should review where necessary.

3.1.1-3.1.7
Teacher-led Discussion/Journal Activity:
Ask students why energy is important to living systems and where the energy for living systems comes from. Have them enter their responses in their journals. As in the last unit, have students also start a concept map of energy and how it relates to living systems.
Emphasize that the need for energy is a fundamental characteristic of all living things. All cells in living things must acquire and expend energy in order to maintain homeostasis.
Differentiate between chemical energy and free energy, stressing that organisms must convert one to the other in order to carry out their life activities. Introduce the first and second law of thermodynamics to students and relate these to the concept of entropy. Build on the concepts of metabolism, catabolism and anabolism. Differentiate between autotrophic and heterotrophic organisms in terms of their anabolic and catabolic biochemistry.

Present a model/diagram to students showing this relationship between photosynthesis and cellular respiration in an ecological setting. Stress that all organisms carry out respiration to produce energy from organic molecules. Introduce the terms exergonic and endergonic as they relate to chemical reactions, using photosynthesis and cellular respiration as examples. Emphasize that these are both enzymatic reactions, the next topic of study.

3.1.8
Cooperative Learning/Research Activity:
Separate students into groups and have them design a simple closed ecosystem, either aquatic or terrestrial. Students must consider all abiotic and biotic factors necessary for sustainability. Allow the students some time for research.

If time allows, you may want students to actually construct these model ecosystems to test their hypotheses.

Suggestions for Assessment

Knowledge

3.1.1-3.1.8
Written test/quiz

Differentiate between autotrophs and heterotrophs in terms of the reactants and products relating to energy flows, i.e. photosynthesis and cellular respiration.

Skills and Processes

3.1.1-3.1.7
Participation in class discussion
3.1.8
Lab - Designing a Closed Ecosystem
Experimental Design
Lab Report

Other Assessment

Journal Writing

Concept Mapping

Cooperative Learning

Suggested Learning Resources

Print

Texts

Biology: A Systems Approach
pages 136, 188, 637-642

Biology of Ourselves

Biology: The Study of Life
pages 107-108, 824-830

Nelson Biology
pages 74-77, 334-335

Biological Science: An Ecological Approach
pages 12-17, 65-66, 82-86

Lab Activities

Biology: The Study of Life - *Nature's Interaction - A Model* (page 827)

Multimedia

Prescribed Learning Outcomes

Topic 3.2: Enzymes

The student will be able to:

3.2.1 Discuss the importance of enzymes as biological catalysts.

3.2.2 Describe the effect of enzymes on the activation energy required for biological reactions.

3.2.3 Measure the pH of a variety of household and/or food substances in the laboratory using pH paper or a pH meter.

3.2.4 Classify a substance as acidic, basic or neutral from it's pH value..

3.2.5 Understand the importance of pH to the functioning biological reactions.

3.2.6 Describe the importance of buffers in maintaining homeostasis in the human body.

Suggestions for Instruction

Entry Level Knowledge:
Students will have had limited exposure to enzymes. They will have been introduced in Senior 2 but not in detail.

3.2.1-3.2.2
Teacher-led Discussion:
Ask students what role enzymes play in maintaining homeostasis in the body. This could be assigned as a research activity.

Introduce the concept of enzymes by explaining that they are biological catalysts and as such, function in regulating all chemical reactions within living organisms. You may wish to present a chart or diagram illustrating how enzymes affect the activation energy necessary to start a reaction.

It will be necessary to introduce the concept of pH before discussing factors that affect enzyme activity.

3.2.3-3.2.6
Cooperative Learning /Lab Activity:
Have students work in groups and perform pH tests on a number of household and food substances using pH paper or a pH meter.
Discuss the pH scale and emphasize the effect that pH has on chemical reactions in cells.
Discuss the pH of certain body fluids such as blood and stomach acid and the importance of maintaining those pH levels for proper enzyme function.
In order to introduce the concept of buffers in living systems, have students attempt to neutralize an acidic or basic solution and compare that to the neutralization of a living tissue homogenate such as liver or potato.
Discuss the importance of buffers in maintaining homeostasis in the body.

Suggestions for Assessment

Knowledge

3.2.1-3.2.6
Written test/quiz

Skills and Processes

3.2.1-3.2.2
Participation in class discussion
3.2.3-3.2.6
Lab - Measuring pH (Buffering)
Performance evaluation

Other Assessment

Journal Writing

Concept Mapping

Cooperative Learning

Suggested Learning Resources

Print

Texts

Biology: A Systems Approach
Chapter 4 - pages 138-140, 142-143

Biology of Ourselves

Biology: The Study of Life
Chapter 4 - pages 68, 50-52

Nelson Biology
Chapter 3 - pages 77, 55-57

Biological Science: An Ecological Approach
Chapter 4 - pages 80, 96

Laboratory Activities

Biology: The Study of Life - *An Investigation of pH* (page 52)
Biological Science: An Ecological Approach - *Organisms and pH* (page 81-82)
Biology: A Systems Approach Lab Manual - *Measuring pH* (page 63)

Multimedia

Prescribed Learning Outcomes

Topic 3.2: Enzymes
continued

The student will be able to:

3.2.7 Conduct an investigation to determine the relationship between the rate of enzyme activity and factors such as:
a) temperature
b) pH
c) substrate concentration
d) competitive inhibitors

3.2.8 Predict the effects of changing temperature, pH, substrate concentration and competitive inhibitors on enzymatic reactions.

3.2.9 Predict how diet can affect enzyme catalyzed reactions through coenzymes and cofactors.

3.2.10 Illustrate and describe the "induced fit" and "lock and key" theories of enzyme action.

Suggestions for Instruction

3.2.7-3.2.8
Cooperative Student Laboratory Activity:
Separate students into groups and have them perform an experiment to identify factors which affect enzyme activity in living systems. There are many good labs available to test this. The enzyme catalase found in liver and potato is good to use in terms of it's ability to decompose hydrogen peroxide. Different variables such as pH, temperature, substrate concentration and competitive inhibitors can be introduced to determine their effect on enzyme activity. Have students prepare a laboratory report on their findings. Discuss the presentation and analysis of experimental data with students so that they may may incorporate this into their laboratory report.

3.2.8-3.2.10
Teacher-led Discussion/Research Activity:
Follow up on the lab activity with discussion on how pH, temperature, substrate concentration and competitive inhibitors affect enzyme action. Emphasize to students that enzymes are protein molecules and as such, are subject to denaturation.

Discuss the role of cofactors and coenzymes in enzymes reactions. Have students hypothesize about the effect that diet has on enzyme reactions. Provide students with hypothetical situations and have them predict the effects on enzyme action.

Present students with the "lock and key" and "induced fit" theories of enzyme action and why the induced fit theory has emerged as the accepted theory. This could be assigned as a research activity.

NOTE:
Some of the laboratory activities suggested on page 7 may be performed in the context of the unit on Nutrition and Digestion. Teachers should use their own discretion on how how they choose to achieve the outcomes related to these activities.

Suggestions for Assessment

Knowledge

3.2.7-3.2.10
Written test/quiz
Present hypothetical situations
Models of enzyme action

Skills and Processes

3.2.7-3.2.8
Lab -Factors Affecting Enzyme Activity
Performance evaluation
Lab Report

3.2.8-3.2.10
Participation in class discussion
Research Report

Other Assessment

Journal Writing

Concept Mapping

Cooperative Learning

Suggested Learning Resources

Print

Texts

Biology: A Systems Approach
Chapter 4 - pages 140-144

Biology of Ourselves

Biology: The Study of Life
Chapter 4 - pages 69-71

Nelson Biology
Chapter 3 - pages 78-81

Biological Science: An Ecological Approach
Chapter 4 - pages 92-96

Laboratory Activities

Biology: The Study of Life -
Enzyme Function (page 72)
Biological Science: An Ecological Approach -
Enzyme Activity (page 93-95)
Nelson Biology - *Enzymes and* H_2O_2 (page 83)
Biology of Ourselves -
pH and Enzyme Activity (p. 269-270)
Nelson Biology -
Effect of pH on Protein Digestion (page 131)
Biology: A Systems Approach Lab Manual -
Enzyme Function (page 67)

Multimedia

Prescribed Learning Outcomes

Topic 3.3: Energy Storage and Transformation

The student will be able to:

3.3.1 Relate the general structure of the ATP molecule to it's role as the "energy currency" of the cell.

3.3.2 Describe several ways in which cells use energy from ATP.

3.3.3 Explain the importance of phosphorylation and electron transport systems to living things.

3.3.4 Differentiate between oxidation and reduction reactions as they apply to cellular metabolism.

3.3.5 Describe the role of NAD^+ as a reducing agent during electron transport.

3.3.6 Predict the effects of a lack of oxygen on energy production in cells.

Suggestions for Instruction

Entry Level Knowledge:
Students will have had little or no exposure to energy storage and transformation.

3.3.1-3.3.6
Teacher-led Discussion:
Ask students to hypothesize how the cell stores the free energy produced from cellular respiration so that it may be used when needed for cellular processes.
Present a model or diagram of the adenosine triphosphate (ATP) molecule, demonstrating the energy storage capacity of the phosphate bonds between the phosphate molecules. Emphasize that the energy for all reactions within cells is provided by ATP in it's conversion to ADP or in some cases, AMP. Give some specific examples of reactions where ATP is used e.g. biosynthesis reactions, nutrient absorption and waste removal reactions, maintaining internal ion concentrations, movement of muscles, cell division, active transport, etc. Make an analogy between the role that ATP plays in energy conversion within the cell to foreign currency conversion. The exchange fee is lost as heat.

Demonstrate and explain to students that the replenishment of ATP from ADP is provided through a process known as phosphorylation, which occurs during the electron transport system of cellular respiration. Present students with a model or diagram of the electron transport system.

Introduce the terms oxidation and reduction as they apply to cellular metabolism. Explain how the transfer of electrons during electron transport produces the energy required to form ATP, emphasizing the role of the coenzyme NAD^+ as a reducing agent by accepting hydrogen protons and electrons n this process.

Explain the role of oxygen as the final electron acceptor in the chain in order that students can relate the need for oxygen to energy production. Discuss under what conditions lactic acid would be produced.

You may want students to research this topic in more detail if the interest and time are available.

Suggestions for Assessment

Knowledge

3.3.1-3.3.6
Written test/quiz
Make connections to:
entropy
enzymes in electron transport

Skills and Processes

3.3.1-3.3.6
Participation in class discussion

Other Assessment

Journal Writing

Concept Mapping

Suggested Learning Resources

Print

Texts

Biology: A Systems Approach
Chapter 6 - 182-188, 191-192

Biology of Ourselves
Chapter 2 - page 75

Biology: The Study of Life
Chapter 6- pages 107-111, 115-119

Nelson Biology
Chapter 3 - pages 84-86

Biological Science: An Ecological Approach
pages 86-87, 404-405

Multimedia

Unit 4

Nutrition and Digestion

Overview
8 hours

Topics	Conceptual/Skill Development
4.1 **Nutrition** 3.5 hours	• molecular size and cell membrane permeability • six basic nutrients • balanced diets • monitor personal nutrient intake
4.2 **Human Digestion** 2.5 hours	• mechanical and chemical digestion • structures of the human digestive system • digestive secretions • nervous and hormonal control of digestion • absorption of nutrients
4.3 **Disorders of the Digestive System** 2 hours	• research activities • digestive disorders/diseases • eating disorders • class debate on diet

Prescribed Learning Outcomes

Topic 4.1: Nutrition

The student will be able to:

4.1.1 Explain the need for digestion in humans i.e., in terms of converting complex organic compounds (eg. starches, proteins) into useable organic nutrients (eg. glucose, amino acids).

4.1.2 Perform an experiment(s) to determine:
- the relationship between molecular size and cell membrane permeability
- the effect of an digestive enzyme on it's substrate.

Suggestions for Instruction

Entry Level Knowledge:
Students may have studied nutrition in health courses. Review where necessary.

4.1.1
Teacher-led Discussion/Journal Entry:
Ask students to explain the statements "you are what you eat" and "junk foods" in their journal. See if students can make the connection between the foods they eat and certain disorders related to diet such as cardiovascular disease, anorexia nervosa, etc.

Make the distinction between autotrophic and heterotrophic nutrition and relate this to photosynthesis and cellular respiration studied in "Energy for Life Processes".

Emphasize that the primary function of the heterotrophic (eg. human) digestive system is to convert the foods consumed into useable organic molecules known as nutrients. These nutrients include proteins, carbohydrates, lipids, vitamins, minerals and water.

Make the connection to the "The Chemistry of Life" unit for students by relating to the enzymatic hydrolysis of carbohydrates, proteins and lipids. Emphasize the need for the cells of the body to obtain the smallest components of these nutrients (eg. glucose, amino acids) in order that they may pass through cell membranes and be used for energy production or in the synthesis of new organic compounds for use in the body.

4.1.2
Cooperative Learning/Student Lab Activity:
Have students work in groups and perform an experiment(s) to demonstrate the relationship between molecular size and cell membrane permeability and the effect of a digestive enzyme on it's substrate. You could use dialysis tubing, starch solution, amylase (diastase) solution and indicators.

Suggestions for Assessment

Knowledge

4.1.1-4.1.2
Written test/quiz

Present hypothetical situations

Students must be aware that the function of the digestive system is to render all nutrients water soluble and small enough to be permeable to cell membranes.

Skills and Processes

4.1.1
Participation in class discussion
4.1.2
Lab -Digestive Enzymes
Performance evaluation
Lab Report

Other Assessment

Journal Writing

Concept Mapping

Cooperative Learning

Suggested Learning Resources

Print

Texts

Biology: A Systems Approach
Chapter 8 - pages 235, 238, 240, 242

Biology of Ourselves
Chapter 7 - page 210

Biology: The Study of Life
Chapter 8 - 149-151

Nelson Biology
Chapter 5 - page 122

Biological Science: An Ecological Approach
pages 85, 394-395

Lab Activities

Biology: The Study of Life - *Digestion of Starch* (page 168)

Multimedia

Prescribed Learning Outcomes

Topic 4.1: Nutrition
continued

The student will be able to:

4.1.3 Describe the functions of the six basic types of nutrients (carbohydrates, lipids, proteins, vitamins, minerals, water) necessary for the normal functioning of the human body.

4.1.4 List one dietary source for each of the six main nutrients necessary for the human diet.

4.1.5 Explain the need for a balanced diet both in terms of satisfying the body's energy requirements and in the prevention of dietary disorders (eg. anorexia, obesity, malnutrition, anemia, cardiovascular disease, etc.).

4.1.6 Collect, analyze, and evaluate data concerning personal nutrient intake.

Suggestions for Instruction

Entry Level Knowledge:
Students may have studied nutrition in health courses. Review where necessary.

4.1.3-4.1.5
Cooperative Learning/Research Activity:
Have students work in groups and research the six major nutrients found in the body, their dietary sources, their function in the body, and some deficiency syndromes related to each. You may want to have each group research a different nutrient. Have students report their findings to the rest of the class. Summarize the student findings in the form of a chart.

4.1.6
Student Activity:
Students should track their food consumption over a three or four day period, itemizing the type of food consumed and the quantity. Have them calculate the energy content and nutrient value in each of these foods using the Canada Food Guide. You may ask them to itemize the ingredients in some of the foods they eat on a regular basis to aid in determining the nutrient value. Have them submit a report on their findings.

Suggestions for Assessment

Knowledge

4.1.3-4.1.5
Written test/quiz

Research Report

Skills and Processes

4.1.6
Lab -Personal Nutrient Intake
Lab Report
Self Evaluation

Other Assessment

Journal Writing

Concept Mapping

Cooperative Learning

Suggested Learning Resources

Print

Texts

Biology: A Systems Approach
Chapter 5 - pages 165-176

Biology of Ourselves
Chapter 7 - pages 208-233

Biology: The Study of Life
Chapter 8 - pages 151-154

Nelson Biology
Chapter 5 - page 122

Biological Science: An Ecological Approach
pages 410-420, 716, 719

Lab Activities
Biology of Ourselves - *Vitamin C*
(page 223-225)
Biology of Ourselves - *A Personal Assessment*
(page 244-247)

Contact Canada Health and Welfare for
Canada Food Guide and related activities

Multimedia

Prescribed Learning Outcomes

Topic 4.2: Human Digestion

The student will be able to:

4.2.1 Identify from a diagram, model, or specimen, the following structures of the human digestive system:
- tongue
- salivary glands
- epiglottis
- liver
- gall bladder
- large intestine
- appendix
- teeth
- esophagus
- stomach
- pancreas
- small intestine
- rectum
- anus

4.2.2 Compare and contrast mechanical and chemical digestion.

4.2.3 Describe the role of sphincters and peristalsis in the digestive process.

4.2.4 Describe the digestive function of the structures in 4.2.1.

4.2.5 Describe the source and function(s) of the following digestive secretions:
- amylase
- pepsin
- bile
- lipase
- maltase
- sodium bicarbonate
- mucus
- HCl
- trypsinogen
- peptidase

4.2.6 Explain the nervous and hormonal control mechanisms that regulate the release of digestive secretions listed in 4.2.5.

4.2.7 Identify and describe the structure and function of villi in the small intestine.

Suggestions for Instruction

4.2.1-4.2.7
Teacher-led Discussion/Journal Entry:
Have students make a journal entry listing and describing all the digestive structures they can.

Present students with a diagram or model of the human digestive system, illustrating the major organs and structures involved.

Teachers may wish to have students perform a dissection to illustrate the mammalian digestive structures on an actual specimen. However, this activity is probably better suited as a wrap-up of all the systems studied throughout the course.

Illustrate the passage of food from the mouth through the anus, emphasizing the physical and chemical processes occurring through each structure. Emphasize the role of peristalsis and sphincters in controlling the flow of food through the digestive tract.

Students should learn the various secretions of each digestive organ, the function of each and the control over it's release. The following activities suggest ways to achieve this.

4.2.1-4.2.6
Cooperative Learning Activity:
Have students work in groups and construct a diagram/chart summarizing the secretions(s) of the major digestive organs, the foods they act on, the end products produced, and the nervous or hormonal influence on their release. Emphasize the need for a coordinated, controlled release of enzymes and digestive juices to ensure an efficient and complete digestive process. Therefore, the role of the nervous system and the endocrine system should be developed here as well.

4.2.7
Present a diagram or model of the inner lining of the small intestine, emphasizing the need for a large surface area for absorption. The structure and function of the villi should be developed with reference to the relationship between the digestive system and the circulatory system.

Suggestions for Assessment

Knowledge

4.2.1-4.2.7
Written test/quiz
Label Diagrams
Fill in Charts

Skills and Processes

4.2.1-4.2.6
Cooperative Learning Activity
Participation in cooperative activities
Observation Checklists

Lab Activity - Mammalian Dissection
Performance Evaluation
Dissection Techniques
Identification of Structures

Other Assessment

Journal Writing

Concept Mapping

Cooperative Learning

Suggested Learning Resources

Print

Texts

Biology: A Systems Approach
Chapter 8 - pages 248-258

Biology of Ourselves
Chapter 8 - page 252-277

Biology: The Study of Life
Chapter 8 - 160-167

Nelson Biology
Chapter 5 - page 123-133

Biological Science: An Ecological Approach
pages 393-398

Lab Activities

Biology of Ourselves -
Chemical Digestion in the Mouth (page 259-260)
Protein Digestion (page 265)
The Action of Lipase on Fats (p. 268-269),
Mammalian Dissection (pages 365-370)
Biology: A Systems Approach Lab Manual -
Starch Digestion (page 123)
Protein Digestion (page 129)

Multimedia

Prescribed Learning Outcomes

Topic 4.3: Disorders of the Digestive System

The student will be able to:

4.3.1 Describe the cause, symptoms, and treatment of five of the following disorders of the digestive system:
- anorexia nervosa
- bulimia
- hyper-vitaminosis
- malnutrition
- ulcers
- gallstones
- lactose intolerance
- appendicitis
- Crone's disease
- colitis
- colon/stomach cancer
- diarrhea
- cholera
- amoebic dysentery
- constipation
- hemmorhoids
- heartburn
- typhoid fever
- bacillary dysentery
- jaundice
- hepatitis
- cirrhosis
- food poisoning

Suggestions for Instruction

Entry Level Knowledge:
Students will have had limited exposure to the human digestive disorders.

4.3.1
Research/Cooperative Learning Activity:
Have students work in groups and research one or more of the following topics/disorders related to the digestive system:
- ulcers
- gallstones
- lactose intolerance
- appendicitis
- Crone's disease
- colitis
- diarrhea
- cholera
- amoebic dysentery
- constipation
- hemmorhoids
- heartburn
- typhoid fever
- jaundice
- bacillary dysentery
- hepatitis
- food poisoning
- cirrhosis
- colon/stomach cancer
- eating disorders (anorexia nervosa, bulimia, hyper-vitaminosis, malnutrition)

Students should report on their research and provide other students with written summaries of their findings.

Class Debate
Structure a class debate on a diet related topic. Some examples include:
- Specialized diet plans may actually contribute to malnutrition in people who use them consistently.
- Modern advertising portrays "the ideal" woman as abnormally thin. Research has shown that many eating disorders (primarily in women) are related to this public perception.

Suggestions for Assessment

Knowledge

4.3.1
Written test/quiz
Research Report
Oral Report

Skills and Processes

4.3.1
Research Activity
Participation in research/report
Presentation of report

Class Debate
Participation in debate

Other Assessment

Journal Writing

Concept Mapping

Cooperative Learning

Suggested Learning Resources

Print

Texts

Biology: A Systems Approach
Chapter 8 - pages 248-258
Chapter 5 - pages 165-176
Biology of Ourselves
Chapter 8 - page 252-277
Chapter 7 - pages 208-233
Biology: The Study of Life
Chapter 8 - 160-167
Chapter 8 - pages 151-154
Nelson Biology
Chapter 5 - page 123-133

Biological Science: An Ecological Approach
pages 393-398, 410-420, 716, 719

Multimedia

Unit 5

Gas Exchange

Overview

5 hours

Topics	Conceptual/Skill Development
5.1 **Respiration** .5 hour	• external, internal, and cellular respiration • conditions necessary for gas exchange
5.2 **Human Respiratory System** 1.5 hours	• structure and function of the human respiratory system • mechanics of breathing (model lung) • measurement of respiration rate and lung capacities
5.3 **Chemistry of Respiration** 1.5 hours	• role of hemoglobin in transporting gases • hemoglobin as a buffer • control of breathing (negative feedback mechanism) • measure carbon dioxide production
5.4 **Respiratory Disorders** 1.5 hours	• research activities • lung cancer, emphysema, bronchitis, asthma, pneumonia, cystic fibrosis • class debate on smoking

Prescribed Learning Outcomes

Topic 5.1: Respiration

The student will be able to:

5.1.1 Define the term gas exchange.

5.1.2 Distinguish between external respiration, internal respiration and cellular respiration.

5.1.3 List four conditions required for gas exchange across a membrane (thin walled, moist, concentration gradient, in contact with the gas, in contact with a transport system)

Suggestions for Instruction

Entry Level Knowledge:
Students may have studied the respiratory system in grade 8. Teachers should check for prior knowledge and review where necessary

5.1.1-5.1.3
Teacher-led Discussion/Journal Activity:
Introduce the topic of gas exchange to students by asking them to hold their breath until instructed to resume (do not allow students to lose consciousness). Have them note the changes which occurred during this activity in their journals. Some reported effects could be increased heart rate, increased face temperature, pressure in their ears, pounding headache, dizziness, grey outs. Have them hypothesize as to why these changes occur. Relate their responses to the role of oxygen in the production of ATP (energy) during cellular respiration studied during the unit on "Energy for Life Processes". Cellular respiration is critical to the proper functioning of all tissues, particularly the nervous system.

Review the chemical equation of cellular respiration with students, noting the consumption of oxygen and release of carbon dioxide (gas exchange) in the process. Emphasize the need for both external (exchange of gases at the lungs) and internal respiration (exchange of gases at the tissue) in multicellular organisms in order to allow cellular respiration to occur.

Provide students with a list of conditions necessary for gas exchange to occur. You may use the context of studying the comparative anatomy and physiology of selected organisms to assist in explaining these conditions. The development of the lung is a fascinating evolutionary story of how organisms adapted to life on land.

Suggestions for Assessment

Knowledge

5.1.1-5.1.3
Written test/quiz
List conditions necessary for gas exchange

Skills and Processes

5.1.1-5.1.3
Discussion/Journal Activity
Participation in Discussion
Journal Entries

Other Assessment

Concept Map

Journal Entries

Suggested Learning Resources

Print

Texts

Biology: A Systems Approach
Chapter 7 - pages 211-212

Biology of Ourselves
Chapter 6 - page 186

Biology: The Study of Life
Chapter 11 - 219-223

Nelson Biology
Chapter 8 - page 186

Biological Science: An Ecological Approach
Chapter 16 -pages 442-443

Multimedia

Prescribed Learning Outcomes

Topic 5.2: Human Breathing

The student will be able to:

5.2.1 Identify the following structures of the human respiratory system from a model or diagram:

lungs	diaphragm
pleura	interpleural fluid
nasal cavity	pharynx
epiglottis	larynx
vocal cords	trachea
bronchi	bronchial tubes
alveoli	

5.2.2 Describe the function of the structures in 5.2.1.

5.2.3 Explain how the structure of alveoli are related their function.

5.2.4 Illustrate and explain the mechanics of breathing in humans, including the role of the diaphragm and intercostal muscles in the changing volume and pressure of the chest cavity.

5.2.5 Measure their own respiration rate and lung capacities, i.e tidal volume, expiratory reserve volume and vital capacity.

Suggestions for Instruction

5.2.1-5.2.3

Teacher-led Discussion:

Have students hypothesize what they think happens when they take a breath. They can enter their responses in their journals.

Present students with a model or diagram of the human respiratory system. Label as a group or have students label their own diagrams relating each structure to it's function. A demonstration dissection (eg. cow lungs) could be performed if these specimens are available. Discuss the structure of the alveoli (large surface area, one cell thick, moist, surrounded by capillaries,) and how that is related to their function (gas exchange between the blood and air).

Diseases/disorders of the respiratory system could be discussed in the context of the structures being discussed or they could be studied as outlined in the last topic of this unit.

5.2.4

Teacher Demonstration/Student Activity:

Have students breath in and out deeply with their hands on their chests. If possible have them listen to their partner's breathing with the use of a stethoscope. Ask them to note their observations in their journals and hypothesize as to what processes are taking place

If possible, construct a model lung using a bell jar, Y-tube, and balloons. This is an excellent tool for demonstrating the volume/pressure relationships related to the mechanics of breathing.

If appropriate supplies are not available to demonstrate the mechanics of breathing, draw diagrams for students illustrating the structures responsible for breathing and the role that these structures play in changing the volume and pressure of the chest cavity.

5.2.5

Cooperative Learning/Lab Activity:

Have students work in groups and perform an activity that measures respiration rate and lung capacities. Spirometers produce excellent results. However, volumetric flasks, plastic pop bottles or balloons can be used as well. You may ask student s to design their own method of measuring lung capacities.

Suggestions for Assessment

Knowledge

5.2.1-5.2.3
Written test/quiz
Identify and describe the function of structures from models, diagrams or specimens.

Skills and Processes

5.2.1-5.2.4
Participation in class discussion
5.2.5
Lab -Lung Capacity
Performance evaluation
Experimental Design
"How is lung capacity related to body mass?"

Other Assessment

Journal Writing

Concept Mapping

Cooperative Learning

Suggested Learning Resources

Print

Texts

Biology: A Systems Approach
Chapter 7 - pages 223-226

Biology of Ourselves
Chapter 6 - pages 186-195

Biology: The Study of Life
Chapter 11 - pages 224-228

Nelson Biology
Chapter 8 - pages 187-191

Biological Science: An Ecological Approach
Chapter 16 -pages 442-443

Lab Activities

Nelson Biology -
Monitoring Lung Volume (page 195)
Biology of Ourselves -
Measuring the Capacity of the Lungs (page 195)
Biology of Ourselves -
Listening to Breathing Sounds (page 193-194)
Biology: A Systems Approach Lab Manual -
Breathing (page 117)
Biology: The Study of Life Lab Manual
Lung Capacity and CO_2 Production (page 87)

Multimedia

Prescribed Learning Outcomes

Topic 5.3: Chemistry of Respiration

The student will be able to:

5.3.1 Describe the role of hemoglobin in transporting oxygen and carbon dioxide in the blood.

5.3.2 Explain how hemoglobin maintains homeostasis in the body by buffering against pH changes in the bloodstream.

5.3.3 Describe the negative feedback mechanisms (chemoreceptors and the medulla oblongata) responsible for the control of breathing in humans.

5.3.4 Predict the effects of varying blood levels of carbon dioxide, oxygen, and carbon monoxide on breathing rate.

5.3.5 Explain the relationship between metabolic rate and carbon dioxide production.

5.3.6 Measure carbon dioxide production as a product of metabolism by exhaling into a solution containing a pH indicator.

Suggestions for Instruction

5.3.1-5.3.5

Teacher-led Discussion/Journal Activity:
Ask students if it is possible to asphyxiate yourself by holding your breath. Also, ask them why breathing increases at high altitudes. Have them hypothesize about these questions and the control, of breathing in their journals.

You should discuss the biochemical events involved in gas transport before discussing the control of breathing. It is important students understand that it is primarily pH which affects breathing rate and not the concentration of gases in the bloodstream.
Present student s with a model or a diagram outlining the biochemical reactions which occur between hemoglobin, oxygen and carbon dioxide, both at the alveolar level and the tissue level. Emphasize the role of hemoglobin as a buffer in picking up bicarbonate ions, thus maintaining homeostasis in the body.
Stress that breathing is an involuntary process which is controlled by blood pH as a result of the amount of CO_2 or O_2 in the blood.

Note the locations of chemoreceptors in the body. Discuss the negative feedback mechanism involved in monitoring and controlling the breathing rate.
Have students predict the effects of varying amounts of CO_2, O_2, and CO in the blood.

Relate the effects of altitude to breathing rate as a result of oxygen levels in the blood.

5.3.6

Cooperative Learning/ Lab Activity:
Separate students into groups and have them perform an activity which measures the rate of carbon dioxide production (as a product of metabolism) by each student. This can be accomplished by using phenolphthalein as an indicator of carbonic acid. Have students exhale into a container until a color change is realized in the indicator (record the time). Measure the amount of 0.04% NaOH required to return the original color. Calculate the number of micromoles of CO_2 produced per minute. Have students compare results with each other and compare before and after exercise results.

Suggestions for Assessment

Knowledge

5.3.1-5.3.5
Written test/quiz
Present hypothetical situations

Skills and Processes

5.3.1-5.2.5
Participation in class discussion
5.3.6
Lab -CO_2 Production and Metabolism
Performance evaluation
Lab Report

Other Assessment

Journal Writing

Concept Mapping

Cooperative Learning

Suggested Learning Resources

Print

Texts

Biology: A Systems Approach
Chapter 7 - pages 226-230

Biology of Ourselves
Chapter 6 - pages 197-201

Biology: The Study of Life
Chapter 11 - pages 229-230

Nelson Biology
Chapter 8 - pages 191-192, 196-198

Biological Science: An Ecological Approach
Chapter 16 - pages 440-444

Lab Activities

CO_2 Production and Metabolism - Activity Guide
Biology: The Study of Life -
Control of Human Breathing Rate (page 232)
Biology of Ourselves -
The Difference Between Inspired Air and Expired Air (page 188)
Biological Science: An Ecological Approach -
Exercise and Carbon Dioxide Production
(page 81-82)

Multimedia

Prescribed Learning Outcomes

Topic 5.4: Respiratory Disorders

The student will be able to:

5.4.1 Describe the cause, symptoms, and treatment of the following disorders of the respiratory system:
- lung cancer
- emphysema
- bronchitis
- asthma
- pneumonia
- cystic fibrosis

Suggestions for Instruction

Entry Level Knowledge:
Students may have had some exposure to the effects of smoking from other courses. However, the other disorders will likely not have been studied.

5.4.1
Research/Cooperative Learning Activity:
Have students work in groups and research one or more of the following topics/disorders related to the respiratory system:
- lung cancer (smoking)
- emphysema
- bronchitis
- asthma
- pneumonia
- cystic fibrosis

Students should report on their research and provide other students with written summaries of their findings.

Class Debate:
Structure a class debate on a smoking related topic. Some examples include:
- Should the government ban the sales of tobacco products?
- Should smoking be allowed in public places?

Suggestions for Assessment

Knowledge

5.4.1
Written test/quiz
Research Report
Oral Report

Skills and Processes

5.4.1
Research Activity
Participation in research/report
Presentation of report

Class Debate
Participation in debate

Other Assessment

Journal Writing

Concept Mapping

Cooperative Learning

Suggested Learning Resources

Print

Texts

Biology: A Systems Approach

Biology of Ourselves
Chapter 6 - pages 202-205

Biology: The Study of Life
Chapter 11 - pages 230-231

Nelson Biology
Chapter 8 - pages 193-194
Case Study: *Smoking and Lung Cancer* (p. 200)
Biological Science: An Ecological Approach
Chapter 16 - pages 440-444

Lab Activities

If time allows, you may wish to pursue these activities:
Biology of Ourselves -
Finding Out About Air Pollution (page 202)
Biology of Ourselves -
How Clean is the Air You Breathe? (page 203)

Multimedia

Unit 6

Circulation

Overview

9 hours

Topics	Conceptual/Skill Development
6.1 **The Circulatory System** 2.5 hours	• importance of circulation to homeostasis • structure and function of blood vessels • heart anatomy and physiology (heart dissection) • tracing blood flow through pulmonary and systemic circulatory systems
6.2 **Heartbeat** 2 hours	• systole and diastole • intrinsic and control of heartbeat (pacemakers) • measure the effect of caffeine and nicotine on heartbeat • measure heart rate (before and after physical activity) • calculate cardiac output
6.3 **Blood Pressure and Fluid Exchange** 1.5 hours	• measure blood pressure • intrinsic and extrinsic factors affecting blood pressure • vasodilation and vasoconstriction • factors affecting arteriolar resistance • blood pressure and fluid exchange
6.4 **The Lymphatic System** 1 hour	• role of the lymphatic system in maintaining homeostasis • identification of lymphatic system anatomy • composition of lymph • identification of lymph vessel structure
6.5 **Cardiovascular Disease** 2 hours	• research activity (various diseases of the cardiovascular system • identification of lifestyle factors that lead to cardiovascular disease

Prescribed Learning Outcomes

Topic 6.1: The Circulatory System

The student will be able to:

6.1.1 List six ways in which the circulatory system maintains homeostasis in the human body.

6.1.2 Explain how the structure of the five different types of blood vessels (arteries, arteriole, veins, venules, capillaries) are related to their function.

6.1.3 Describe how the structure of the heart is related to it's function, i.e. double pump.

6.1.4 Identify and trace blood flow through the following structures of the heart from a specimen, model, or diagram:
- left and right atria
- left and right ventricle
- left and right pulmonary arteries
- left and right pulmonary veins
- superior/inferior venae cavae
- septum
- aorta
- left and right semilunar valves
- left and right atrioventricular valves

6.1.5 Describe the difference between the systemic and pulmonary circulatory system.

6.1.6 Identify the following systemic blood vessels from a specimen, model, or diagram:
- carotid arteries
- jugular veins
- subclavian artery and vein
- superior/inferior venae cavae
- coronary artery and vein
- renal artery and vein
- iliac artery and vein
- hepatic portal vein

Suggestions for Instruction

Entry Level Knowledge:
Students will have studied the circulatory system in Grade 8. Review where necessary.

6.1.1
Discussion/Journal Entry:
Using a brainstorming session and a journal entry, ask the question "Why is a circulatory system necessary?" The following functions of the circulatory system should be highlighted: *allows gas exchange, delivers nutrients, picks up cellular waste, allows temperature regulation, assists immune delivery, delivers hormones, closes wounds with clotting*
Make the connections between the circulatory system and the other human systems, emphasizing the role that the circulatory system plays in maintaining homeostasis. Have students begin a concept map of circulation.

6.1.2
Teacher-led Discussion:
Illustrate and discuss the structure of arteries, arterioles, veins, venules and capillaries. Note differences in the types of tissue present and how these differences are related the function of the vessel.

6.1.3-6.1.6
Teacher-led Discussion/Lab Activity:
Present students with a diagram or model of the human circulatory system, illustrating the heart and major blood vessels. Explain the "double pump" anatomy and physiology of the heart. Obtain a beef, sheep or pig heart(s) from the local butcher or farmer and either have students dissect the organ or do a demonstration dissection. Identify the major blood vessels entering and leaving the heart as well as the major structures found within the heart.

6.1.4-6.1.6
Student Activity:
Hand out blank diagrams of the heart and circulatory system to students. Have them label all major structures. Using blue pencil (deoxygenated) and red pencil (oxygenated), ask students to trace the flow of blood through the heart and major blood vessels.

Suggestions for Assessment

Knowledge

6.1.1-6.1.6
Written test/quiz
Label Diagrams
Fill in Charts

Skills and Processes

6.1.1
Participation in class discussion

6.1.4, 6.1.6
Identify structures from a model or specimen
Label diagram illustrating blood flow

6.1.4
Lab Activity - Heart Dissection
Performance Evaluation

Other Assessment

Journal Writing

Concept Mapping

Cooperative Learning

Suggested Learning Resources

Print

Texts

Biology: A Systems Approach
Chapter 9 - pages 281-284

Biology of Ourselves
Chapter 5 - pages 164-173

Biology: The Study of Life
Chapter 9 - pages 177-193

Nelson Biology
Chapter 6 - pages 138-148

Biological Science: An Ecological Approach
Chapter 16 - pages 424-427

Laboratory Activities

Biology of Ourselves -
Heart Dissection (pages 172-173)
Biology: The Study of Life -
The Mammalian Heart (page 190)

Circulatory System Diagrams are available from the Manitoba Heart Foundation
301-352 Donald Street, Winnipeg, MB
R3B 2H3

Multimedia

Prescribed Learning Outcomes

Topic 6.2: Heartbeat

The student will be able to:

6.2.1 Differentiate between systole and diastole and relate these to heart sounds.

6.2.2 Describe the intrinsic control of heartbeat, i.e., nervous (SA Node, AV Node, Perkinje Fibers, Bundle of HIS), and chemical (adrenaline, noradrenaline).

6.2.3 Explain the role of pacemakers in regulating heartbeat.

6.2.4 Describe the effects of extrinsic factors such as caffeine and nicotine on heart rate.

6.2.5 Measure their own heart rate.

6.2.6 Explain the effect of physical activity on heart rate.

6.2.7 Calculate cardiac output given heart rate and stroke volume.

6.2.8 Relate cardiac output to fitness levels.

Suggestions for Instruction

Discussion/Journal Entry:
Ask students a number of questions related to their conceptions of heartbeat i.e., can they control their own heartbeat? what factors affect heart rate? why do certain people need pacemakers?

6.2.1-6.2.4
Teacher-led Discussion/Student Activity:
Have students listen to their own heartbeat or a partner's heartbeat using a stethoscope. Discuss the familiar "lubb-dubb" heart sounds and the relationship of these sounds to systole and diastole.
Discuss the control of heartbeat with students. Emphasize the fact that the heart is composed of cardiac muscle tissue which is myogenic and as such, has the ability to contract without external nerve stimulation and will continue to beat (for a short time) when removed from the body. Outline the role of the SA Node, AV Node, Bundle of HIS, and Perkinje fibers in controlling heartbeat. Discuss the need for pacemakers in some individuals and how these devices aid in controlling heart rate.
Explain the effect of hormones such as epinephrine and norepinephrine on heart rate. Relate this effect to certain "fight or flight" situations. Discuss extrinsic factors such as caffeine and nicotine and their effects.

6.2.5-6.2.8
Cooperative Learning/Student Lab Activity:
Separate students in to groups and do a lab on human heart rate. Determine the effects of physical activity on heart rate and have students calculate cardiac output based on their results. Compare class heart rates of different individuals and have students attempt to hypothesize as to why differences exist (e.g. body size, athletes, smokers). Lab report can be submitted, entered in their journal, or turned in as part of a portfolio of the student's lab work.

6.2.4
Student Lab Activity/Teacher Demonstration:
If time allows, a student lab or teacher demonstration could be performed to determine the effect of caffeine and nicotine on heart rate in daphnia.

Suggestions for Assessment

Knowledge

6.2.1-6.2.8
Written test/quiz
Label Diagrams
Present hypothetical situations

Skills and Processes

Participation in class discussion

6.2.1
Identification of heart sounds using a stethoscope

6.2.5-6.2.8
Lab Activity - Human Pulse Rate
Performance Evaluation
Cooperative Learning
Calculate cardiac output

Lab Report

Other Assessment

Journal Writing

Concept Mapping

Cooperative Learning

Suggested Learning Resources

Print

Texts

Biology: A Systems Approach
Chapter 9 - pages 285-287

Biology of Ourselves
Chapter 5 - pages 173-176

Biology: The Study of Life
Chapter 9 - pages 180-182

Nelson Biology
Chapter 6 - pages 149-154

Biological Science: An Ecological Approach
Chapter 16 - pages 423-424, 466, 468

Laboratory Activities

Biology of Ourselves - *Heart Sounds* (page 171)
Biology of Ourselves - *Pulse Rate* (pages 175-176)
Biology: A Systems Approach Lab Manual - *The Human Heart Rate* (page 151)
Biological Science: An Ecological Approach - *Exercise and Pulse Rate* (pages 423-424)
Biology: The Study of Life Lab Manual *Investigating Pulse Rate* (page 77)

Multimedia

Prescribed Learning Outcomes

Topic 6.3: Blood Pressure and Fluid Exchange

The student will be able to:

6.3.1 Identify and measure systolic and diastolic blood pressure using a sphygmomanometer.

6.3.2 List and describe extrinsic factors (e.g., exercise, caffeine, nicotine) which affect transient blood pressure.

6.3.3 Differentiate between vasodilation and vasoconstriction.

6.3.4 Describe the control of blood pressure by the autonomic nervous system

6.3.5 List and describe factors which affect arteriolar resistance.

6.3.6 Explain how changes in blood pressure help to maintain homeostasis in the body.

6.3.7 Explain how blood pressure and osmotic pressure contribute to fluid exchange at the capillary level.

Suggestions for Instruction

6.3.1-6.3.2
Cooperative Learning/Lab Activity:
Demonstrate the proper use of a sphygmomanometer. Group students in pairs or threes and have them measure each other's blood pressure. Students can then measure B.P. at rest, after exercise. Make comparisons between individuals (e.g. smokers and non-smokers, athletes and non-athletes) and have students hypothesize reasons for the differences. Lab report can be submitted, entered in their journal, or turned in as part of a portfolio of the student's lab work.

6.3.3
Teacher/Student Demonstration:
Using cold water or air, show the constriction of capillaries in the skin. Using a volunteer i.e., gym student, show vasodilation of capillaries of skin after moderate exercise, i.e., running laps.

6.3.4-6.3.6
Teacher-led Discussion/Journal Activity:
Using journal entries and discussion, have students discuss how blood pressure changes during episodes of anger, fear, or embarrassment. Such episodes can be drawn largely from students' past experience during group discussion. Point out changes such as rising or falling blood pressure and reddening or paling of skin colour during response. Relate these to the autonomic nervous system and it's control over blood pressure
Emphasize that blood pressure variation is due largely to the diameter of arteries. Discuss factors which affect arteriolar resistance, such as epinephrine, sympathetic nerve stimulation, lactic acid accumulation, CO_2 accumulation.

Discuss the connection between these factors and the body's attempt to maintain homeostasis.

6.3.7
Student Activity/Teacher Demonstration:
Students should draw several cells showing tissue fluid in the interstitial spaces and the capillary supplying those cells. Using arrows, have them illustrate blood pressure and osmotic pressure at the arteriole end and venous end of the capillary, illustrating nutrient and gas exchange at each end.

Suggestions for Assessment

Knowledge

6.3.2-6.3.7
Written test/quiz
Label Diagrams
Present hypothetical situations

Skills and Processes

6.3.1-6.3.2
Lab Activity - Human Blood Pressure
Performance Evaluation(measuring BP)
Cooperative Learning
Lab Report

6.3.4-6.3.6
Participation in class discussion

6.3.7
Diagram showing fluid exchange at the capillary level

Other Assessment

Journal Writing

Concept Mapping

Cooperative Learning

Suggested Learning Resources

Print

Texts

Biology: A Systems Approach
Chapter 9 - pages 286-287

Biology of Ourselves
Chapter 5 - pages 176-181

Biology: The Study of Life
Chapter 9 - pages 182-184

Nelson Biology
Chapter 6 - pages 154-159

Biological Science: An Ecological Approach
Chapters 16, 17 - pages 429, 468

Laboratory Activities

Biology of Ourselves -
Blood Pressure (page 179)
Nelson Biology -
Effects of Posture on Blood Pressure (page 157)

Multimedia

Prescribed Learning Outcomes

Topic 6.4: The Lymphatic System

The student will be able to:

6.4.1 Describe the function of the lymphatic system in the human body.

6.4.2 List the components of lymph in the human body, i.e., fat, protein, water, white blood cells.

6.4.3 Identify the following structures of the lymphatic system from a specimen, model, or diagram:
- adenoids
- tonsil
- lymph nodes
- spleen
- thoracic duct

6.4.4 Differentiate between lymph vessels and blood vessels.

Suggestions for Instruction

Entry Level Knowledge:
Students will have studied the lymphatic system in Senior 2 in terms of it's role in cancer. Review where necessary.

6.4.1-6.4.3
Teacher-led Discussion/Journal Activity:
Ask students what they believe is the role of the lymphatic system. Have them enter their responses in their journals. Discuss the function of the lymphatic system as a secondary circulatory system and it's role in immunity. Present a diagram or model of the human lymphatic system to students highlighting:
a. adenoids
b. tonsils
c. lymph nodes
d. spleen
e. thoracic duct

Discuss the composition of lymph with students. Have students attempt to explain why these components are found in the lymph. Emphasize the importance of each component and what eventually happens to these substances.

6.4.4
Student Activity:
Students should examine diagrams or prepared slides showing cross sections of lymph vessels and blood vessels. Have students draw diagrams from the prepared slides.

Suggestions for Assessment

Knowledge

6.4.1-6.4.4
Written test/quiz
Label Diagrams

Skills and Processes

6.4.4
Draws diagrams of blood vessels from prepared slides.

Other Assessment

Journal Writing

Concept Mapping

Cooperative Learning

Suggested Learning Resources

Print

Texts

Biology: A Systems Approach
Chapter 9 - pages 289-290

Biology of Ourselves
Chapter 5 - page 167

Biology: The Study of Life
Chapter 9 - pages 188-189

Nelson Biology
Chapter 6 - page 160

Biological Science: An Ecological Approach
Chapter 16 - pages 429-430

Multimedia

Prescribed Learning Outcomes

Topic 6.5: Cardiovascular Disease

The student will be able to:

6.5.1 Describe the effects an aneurysm may have on the body.

6.5.2 Explain the dangers of atherosclerosis and the risk factors that accelerate its development.

6.5.3 Describe angina and the factors that can cause this condition.

6.5.4 Explain 3 possible medical procedures used to rectify atherosclerosis (i.e., coronary bypass, angioplasty, drug therapy).

6.5.5 Distinguish between congenital heart defects and those related to lifestyle.

6.5.6 Discuss lifestyle factors which contribute to heart disease, i.e., smoking, obesity, diabetes, diet, kidney problems.

Suggestions for Instruction

6.5.1-6.5.5
Cooperative Learning/Research Activity:
Students may be divided into groups to research the following disorders:
- aneurysm
- atherosclerosis
- angina
- arrhythmia
- hemorrhage
- septal defect
- edema.

The following headings may be suggested as guidelines:
a. cause
b. effect
c. symptoms
d. treatment
e. prognosis
Students should report on their research and provide other students with written summaries of their findings.

6.5.5
Student Activity/Guest Lecturer:
Play the game of "RISKO" to make students aware of the relationship between lifestyle choices and cardiovascular fitness,
OR
Perform an activity to assess the risk of cardiovascular disease
OR
A guest speaker (e.g. Public Health Nurse) can be invited to discuss techniques to promote heart-healthy lifestyles.

Suggestions for Assessment

Knowledge

6.5.1-6.5.6
Written test/quiz
Present hypothetical situations
Research Report

Skills and Processes

6.5.1-6.5.6
Research Report - Oral or Written

Other Assessment

Journal Writing

Concept Mapping

Cooperative Learning

Suggested Learning Resources

Print

Texts

Biology: A Systems Approach
Chapter 9 - page 288

Biology of Ourselves
Chapter 5 - pages 176-181

Biology: The Study of Life
Chapter 9 - pages 182-183

Nelson Biology
Chapter 6 - pages 141-159

Biological Science: An Ecological Approach
Chapter 15 - pages 410-417

Activities

Biological Science: An Ecological Approach - *Assessing Risk for Cardiovascular Disease* (pages 411-414)

"RISKO" is available from:
American Heart Association
7320 Greenville Avenue,
Dallas, Texas, USA
75231.

Multimedia

Unit 7

Blood and Immunity

Overview

9 hours

Topics	Conceptual/Skill Development
7.1 **Blood Components** 2.5 hours	• importance of blood in homeostasis • structure and function of blood components. • observation and identification of blood cells • diagnosis of disease from blood examination • blood clotting
7.2 **Blood Groupings and Blood Disorders** 1.5 hours	• antigens and antibodies • ABO blood groups • Rh factor (erythroblastosis fetalis) • predicting blood transfusions • research activity - Rh, forensics, blood disorders
7.3 **Immunity** 3 hours	• cell mediated and antibody mediated immunity • role of phagocytes, lymphocytes, T-cells, B-cells • model of immune response • passive and active immunity
7.4 **Disorders of the Immune System** 2 hours	• research activities- biotechnology and immunity, tissue rejection, allergies, auto-immune disease, AIDS • class debate on AIDS

Prescribed Learning Outcomes

Topic 7.1: Blood Components

The student will be able to:

7.1.1 Describe the three major functions of blood in the human body i.e. transport, regulation, protection.

7.1.2 List the components of blood by percentage volume i.e. blood cells, plasma.

7.1.3 Differentiate between erythrocytes, leukocytes and platelets in terms of appearance, origin, numbers and function in the body.

7.1.4 Identify the following cellular components of blood from prepared specimen(s), diagram(s), photograph(s) or electron micrograph(s): erythrocytes, the five main types of leukocytes, and platelets

7.1.5 Explain how blood tests are used to diagnose different blood diseases e.g. leukemia, mononucleosis, anemia, tuberculosis, mumps, etc..

7.1.6 Analyze hematocrits in an attempt to identify blood disorders.

7.1.7 Illustrate the sequence of biochemical events in a blood clotting reaction.

7.1.8 Predict the potential danger of blood clots in different areas of the body, i.e.heart, brain.

Suggestions for Instruction

Entry Level Knowledge:
Students will have studied the circulatory system in grade 8. Review where necessary.

7.1.1
Teacher-led Discussion/Journal Entry:
Ask students to list 5 to 10 statements that they believe correct about blood in their journal. Discuss these with students, emphasizing the three major functions of blood, i.e. transport, regulation, protection. Have students start a concept map for this unit.

7.1.2 - 7.1.3
Teacher-led Discussion:
Present a chart or diagram outlining the major components of the blood and the function of each component. In reference to the cellular components, incorporate appearance, numbers of cells/unit volume and origin.

7.1.4
Cooperative Learning/Student Lab Activity:
Have students work in groups and observe a prepared slide of human blood under the microscope. Students should be able to identify erythrocytes, the five different leukocytes and platelets. They may need to scan different fields to accomplish this. Have them draw diagrams of their observations, estimating the size of the cells and the comparative numbers.

7.1.5-7.1.6
Cooperative Learning/Case Studies:
Follow up on the lab activity by discussing the diagnosis of different diseases by way of observing blood under the microscope. Perform case studies with groups of students where they are presented with various hematocrits. Have them attempt to diagnose certain diseases on the basis of the results of their calculations.

7.1.7 - 7.1.8
Teacher-led Discussion:
Present a model/diagram outlining the series of physical and biochemical events of a blood clotting reaction. Discuss the potential danger of blood clots in different parts of the body i.e. heart attack, stroke.

Suggestions for Assessment

Knowledge

7.1.1-7.1.8
Written test/Quiz
Fill in chart summarizing blood components
Present hypothetical situations

Skills and Processes

7.1.1-7.1.3, 7.1.5-7.1.8
Participation in class discussion

7.1.4
Performance test
Observation and identification of blood cells under the microscope.
Laboratory Report
Diagrams of blood cells
Calculation/estimation of blood cell size

Other Assessment

Journal Entries

Concept Mapping

Cooperative Learning

Suggested Learning Resources

Print

Texts

Biology: A Systems Approach
Chapter 9 - pages 278-280

Biology of Ourselves
Chapter 5 - pages 156-162

Biology: The Study of Life
Chapter 10 - page 195-200

Nelson Biology
Chapter 7 - pages 164-170

Biological Science: An Ecological Approach
Chapter 16 - pages 427-429

Laboratory Activities

Biology of Ourselves -
Examining Blood Cells (page 160-161)
Biology: The Study of Life -
Observing Blood Cells (page 214)
Biology: The Study of Life Lab Manual
Investigating Blood (page 81)
Nelson Biology
Microscopic Examination of Blood (page 169)
Nelson Biology
Diagnosis using Hematocrits (page 170)

Multimedia

Prescribed Learning Outcomes

Topic 7.2: Blood Groupings and Blood Disorders

The student will be able to:

7.2.1 Differentiate between blood antigens and blood antibodies.

7.2.2 Illustrate the differences between the ABO blood groups.

7.2.3 Explain how the rhesus factor can have implications for blood transfusions.

7.2.4 Describe the disease erythroblastosis fetalis and possible preventative treatment for this condition.

7.2.5 Explain the terms universal donor and universal recipient in reference to blood groups.

7.2.6 Predict the physiological consequences of blood transfusions involving different blood types.

7.2.7 Discuss how the study of blood can be used in forensic science.

7.2.8 Discuss Manitoba's contribution to the field of Rh research.

7.2.9 Describe the cause, symptoms, and treatment of the following disorders of the blood:
- anemia
- mononucleosis
- leukemia
- hemophilia

Suggestions for Instruction

Entry Level Knowledge:
Students may have had exposure to blood groupings in Grade 8. Teachers should review where necessary.

7.2.1-7.2.5
Teacher-led Discussion:
Ask students if are aware of their blood type. and why the knowledge of blood types is important, especially when transfusions and pregnancies are involved.
Introduce the concept of antigens and antibodies. Emphasize that antibodies are produced only in response to antigens which are foreign to the body.

Present a chart to students outlining the 4 different blood groups (A, B, AB, O). Indicate the glycoprotein antigen present (or absent) on the RBC's and the antibody present (or absent) in the serum for each blood group. Explain the terms universal donor and universal recipient. While it is not allowable for students to test their own blood types in a classroom situation, you may wish to demonstrate the procedure using your own blood or use simulated blood from a scientific supply house.
Discuss Rh factor with students and it's implications for blood transfusions and pregnancies. Discuss erythroblastosis fetalis and possible preventative treatment for this condition.

7.2.5-7.2.6
Case Studies:
Present case study situations to students involving transfusions of different blood types and have them predict the effects.

7.2.7-7.2.9
Research/Cooperative Learning Activity:
Have students work in groups and research one of the following:
- the use of blood in forensics
- Manitoba's contribution to the field of Rh research.
- blood disorders: anemia, mononucleosis, leukemia, hemophilia,

Students should present their findings to the class in a written/oral report.

Suggestions for Assessment

Knowledge

7.2.1-7.2.9
Written test/Quiz
Fill in Chart on Blood Groups
Present hypothetical situations

Skills and Processes

7.2.6
Prediction of incompatible blood transfusions
7.2.7-7.2.9
Oral/Written Report - Research Activity
Cooperative Learning Activity - How well did each student perform their role?

Other Assessment

Concept Mapping

Cooperative Learning

Journal Entries

Suggested Learning Resources

Print

Texts

Biology: A Systems Approach
Chapter 20 - pages 571-572

Biology of Ourselves
Chapter 5 - pages 162-164

Biology: The Study of Life
Chapter 10 - page 206-210

Nelson Biology
Chapter 7 - pages 171-174

Biological Science: An Ecological Approach
Chapter 16 - pages 439-440

Laboratory Activities

Biology: The Study of Life Lab Manual
Investigating Blood (page 81)
Biology: A Systems Approach Lab Manual -
Human Blood Types (page 281)
*NOTE: Only as a demonstration or using simulated blood.

Multimedia

Prescribed Learning Outcomes

Topic 7.3: Immunity

The student will be able to:

7.3.1 Describe the non-specific protective mechanisms against pathogens found in all vertebrates (i.e. physical and chemical barriers, inflammatory response).

7.3.2 Differentiate between cell mediated and antibody mediated immunity

7.3.3 Describe the role of the cellular and non-cellular components of the blood in immunity i.e.phagocytes, complement, lymphocytes, T cells (killer, helper, suppressor, memory) and B cells in immunity.

7.3.4 Differentiate between the primary and secondary immune response.

7.3.5 Differentiate between passive and active immunity.

7.3.6 Explain how a vaccination or immunization may prevent a person from contracting a disease.

7.3.7 Design a simulation or model of the functioning of the main components of the human immune system.

Suggestions for Instruction

Entry Level Knowledge:
Students will have some background knowledge in immunity from Senior 2 in the context of the study of cancer. Teachers should review where necessary.
Due to the complexity of this topic,the treatment of it here is intended to only provide students with a general understanding of immunity so that they may see how it affects them personally and how it affects society.

Teacher-led Discussion/Journal Activity:
There are many different contexts you could use to introduce this topic to students. A possibility may be to ask to students to write down all the infections/diseases that they have had in their lifetime and attempt to explain the source, reaction and treatment for each. Discuss any vaccinations they may have had. You could use the disease AIDS as a context for explaining the functioning of the immune system as well. A historical perspective could also be provided on the discovery of immunity eg. Jenner, Pasteur.

7.3.1-7.3.6
Teacher-led Discussion:
Discuss the non-specific protective mechanisms found in all vertebrates (i.e. physical and chemical barriers, inflammatory response). Most texts refer to the terms "first-line" and "second-line" of defense. Differentiate between cell mediated and antibody mediated immunity, outlining the types of cells and reactions involved with each (i.e. phagocytes, complement, lymphocytes, T cells (killer, helper, suppressor, memory) and B cells). Distinguish between the primary and secondary immune response. Discuss the differences between passive and active immunity giving examples to students for each. Use the vaccination as an example of active immunity.

7.3.7
Student Activity:
Have students design their own simulation or model of the immune response in the form of a chart, concept map, computer animation, etc.. Have them predict how the immune system would react to different hypothetical situations involving antigens.

Suggestions for Assessment

Knowledge

7.3.1-7.3.7
Written test/quiz
Label Diagrams
Present hypothetical situations

Skills and Processes

7.3.1-7.3.6
Participation in class discussion

7.3.7
Design Model of the Immune System

Other Assessment

Journal Writing

Concept Mapping

Cooperative Learning

Suggested Learning Resources

Print

Texts

Biology: A Systems Approach
Chapter 9, 26 - pages 279-280, 760 - 766

Biology of Ourselves
Chapter 5 - pages 156-158

Biology: The Study of Life
Chapter 10 - pages 201-205

Nelson Biology
Chapter 7 - pages 174-181

Biological Science: An Ecological Approach
Chapter 16 - pages 430-437

NOTE: There are very good lessons and activities (pages 16-29) in the booklet entitled *"Biotechnology for a Healthier World"* (Connaught Laboratories, 1993) distributed to all biology teachers in 1994-95.

Laboratory Activities

Biology: The Study of Life -
The Immune System (page 207)
Biological Science: An Ecological Approach -
The Alpine Slide Mystery (pages 435-437)

Multimedia

Prescribed Learning Outcomes

Topic 7.4: Disorders of the Immune System

The student will be able to:

7.4.1 Explain how the use of biotechnology such as monoclonal antibodies can assist preventing some immune system disorders or diseases such as leukemia.

7.4.2 Explain the causes and process of tissue rejection following an organ transplant and outline methods used to control this problem.

7.4.3 Demonstrate an understanding of the transmission, effect on the immune system, symptoms, and treatment of acquired immune deficiency syndrome (AIDS).

7.4.4 Describe the physiological responses associated with mild and severe allergic reactions (e.g. asthma, anaphylactic shock, insect and snake bites).

7.4.5 Define auto-immune disease and give examples of this disease i.e. lupus, multiple sclerosis, rheumatic fever, arthritis, Hodgkin's disease, etc..

Suggestions for Instruction

7.4.1-7.4.5

Research/Cooperative Learning Activity:
Have students work in groups and research one of the following topics related to the immune system:

- biotechnology and immunity (e.g. monoclonal antibodies and leukemia)
- organ transplants and tissue rejection
- allergies/allergic reactions (asthma, anaphylactic shock)
- auto-immune disease - lupus, multiple sclerosis, rheumatic fever, arthritis, Hodgkin's disease,
- AIDS

Students should report on their research and provide other students with written summaries of their findings.

Class Debate:
Structure a class debate on one of the following AIDS related topics:

- Allowing HIV positive health care workers/teachers to continue working in the field.
- Government compensation of hemophiliacs who contract HIV from blood transfusions.
- Allowing immigration privileges to HIV positive candidates.
- Should HIV positive individuals be listed on a registry such as other STD's?

Suggestions for Assessment

Knowledge

7.4.1-7.4.5
Written test/quiz
Present hypothetical situations
Research Report

Skills and Processes

7.4.1-7.4.5
Research Report - Oral or Written

Class Debate
Participation in debate

Other Assessment

Journal Writing

Concept Mapping

Cooperative Learning

Suggested Learning Resources

Print

Texts

Biology: A Systems Approach
Chapter 9, 26 - pages 279-280, 760 - 766

Biology of Ourselves
Chapter 5 - pages 156-158

Biology: The Study of Life
Chapter 10 - pages 205, 210-213

Nelson Biology
Chapter 7 - pages 174-181

Biological Science: An Ecological Approach
Chapter 16 - pages 430-440

Multimedia

Unit 8

Excretion

Overview

5 hours

Topics	Conceptual/Skill Development
8.1 **Excretory Organs** 1 hour	• excretion and homeostasis • metabolic wastes • role of skin, kidneys, lungs, intestine, liver in excretion
8.2 **Urinary System** 2.5 hours	• structure and function of the human urinary system • anatomy and physiology of the nephron • analysis of water and solute concentration in the nephron • role of ADH and aldosterone in maintaining homeostasis • diuretics
8.3 **Disorders of the Urinary System** 1.5 hours	• diabetes, kidney stones, urinary infections, etc. • kidney dialysis • urinalysis

Prescribed Learning Outcomes

Topic 8.1: Excretory Organs

The student will be able to:

8.1.1 Define the term excretion.

8.1.2 Describe how excretion aids in maintaining homeostasis in the body.

8.1.3 Differentiate between excretion and secretion.

8.1.4 List the primary metabolic wastes produced in human body (i.e., carbon dioxide, water, ammonia, mineral salts) and the source of each.

8.1.5 Compare the role of the major excretory organs (kidneys, lungs, skin, intestine, liver) in the excretory process.

8.1.6 Predict the effect(s) of malfunctioning excretory organs on homeostasis in the human body.

Suggestions for Instruction

Entry Level Knowledge:
Students will have had little or no exposure to excretion.

Teacher-led Discussion/Journal Activity:
Pose the following questions to students. Why do people who have malfunctioning kidneys require dialysis treatments? Why do beverages such as caffeine and alcohol cause frequent urination? What causes a "hangover"? Why can't we drink salt water to prevent dehydration? Are perspiration and urine similar fluids? What are kidney stones? Have students enter their responses to these questions and any questions they have about excretion in their journal. Revisit these questions after this system is completed to determine if they have been answered.

8.1.1-8.1.6
Teacher-led Discussion
Define the term excretion for students. Stress why the human excretory organs are vital to homeostasis in the human body, i.e. in the removal of metabolic wastes and in balancing water and glucose concentrations. Make the distinction between excretion and secretion.

Discuss the production of metabolic wastes by cells and relate the production of these wastes to the energy producing processes discussed in the unit on "Energy for Life Processes". Make connections to the digestive and respiratory systems studied earlier as well.

Construct a chart with students outlining the major excretory organs of the human body, the wastes they are responsible for removing, and the source of the metabolic waste produced. Emphasize the role of the liver in converting ammonia to urea and in detoxifying other substances such as alcohol and poisons.

Present students with hypothetical situations where certain excretory organs are malfunctioning. Have the students predict the effects on the homeostasis in the body, e.g. malfunctioning kidneys would result in a build-up of nitrogenous wastes in the blood and would upset the water-salt balance of the blood.

Suggestions for Assessment

Knowledge

8.1.1-8.1.6
Written test/quiz
Fill in chart summarizing excretory organs and their functions.
Present hypothetical situations.

Skills and Processes

8.1.1-8.1.6
Discussion/Journal Activity
Participation in Discussion
Journal Entries

Other Assessment

Journal Entries

Concept Mapping

Suggested Learning Resources

Print

Texts

Biology: A Systems Approach
Chapter 10 - pages 295-302, 307-309

Biology of Ourselves
Chapter 16 - pages 282-283

Biology: The Study of Life
Chapter 12 - pages 237-238, 241-242, 246-247

Nelson Biology
Chapter 9 - pages 204-205

Biological Science: An Ecological Approach
Chapter 16 - pages 442-444

Multimedia

Prescribed Learning Outcomes

Topic 8.2: The Urinary System

The student will be able to:

8.2.1 Identify on a diagram or model the following structures of the human urinary system:
- kidneys
- renal arteries and veins
- ureters
- urinary bladder
- urethra

8.2.2 Describe the function of the structures in 8.2.1.

8.2.3 Identify on a diagram, model, or specimen the following structures of the kidney:
- renal cortex
- renal medulla
- renal pelvis

8.2.4 Identify from a diagram or model the following structures of the nephron:
- afferent and efferent arterioles
- glomerulus
- Bowman's capsule
- proximal convoluted tubule
- peritubular capillaries
- Loop of Henle
- distal convoluted tubule
- collecting duct

8.2.5 Describe the function of the structures in 8.2.4 in terms of filtration, reabsorption, and secretion.

8.2.6 Analyze water and solute (glucose, protein, urea, Na^+, K^+) concentration in various parts of the nephron and urine.

8.2.7 Describe the role of antidiuretic hormone (ADH) in maintaining water balance in the body.

8.2.8 Describe the role of aldosterone in maintaining blood pressure in the body.

8.2.9 Explain the effect of diuretics such as caffeine and alcohol on water loss.

Suggestions for Instruction

8.2.1-8.2.3
Teacher-led Discussion:
Present students with a model or diagram outlining the major structures of the urinary system. Briefly describe the function of each.

Demonstration/Dissection:
Obtain a beef or pig kidney(s) from the local butcher or farmer and dissect the organ. Identify the major blood vessels supplying the kidney and the major areas of the kidney from a cross section. Explain how the nephron is oriented in relation to the structure of the kidney.

8.2.4-8.2.5
Teacher-led Discussion:
Present students with a diagram or model of the nephron and identify the major structures and their function. Consider constructing a chart listing the major structures and identifying their function in terms of filtration, reabsorption, and secretion.
Provide students with a diagram representing a cross section of nephron, illustrating the passive and active transport processes which occur.

8.2.6
Cooperative Learning Activity:
Separate students into groups and present them with data relating to water and solute concentration obtained from:
a) blood vs. urine sample
b) samples along various points of the nephron.
Ask students a number of discussion questions relating to the data presented. Students may have to do some research to answer some of these questions. Have the students present their findings.

8.2.7-8.2.9
Teacher-led Discussion/Student Activity:
Discuss the influence of the nervous system and endocrine system (ADH, aldosterone) on water reabsorption in the collecting duct and the regulation of blood pressure. These are excellent examples of negative feedback mechanisms. Have students draw diagrams to represent the feedback mechanisms involved. Discuss the effects of the diuretics such as caffeine and alcohol on ADH production.

Suggestions for Assessment

Knowledge

8.2.1-8.2.9
Written test/quiz
Label diagrams
Explain processes in nephron
Draw diagrams of negative feedback mechanisms

Skills and Processes

8.2.1-8.2.3
Dissection
Identify structures from specimen

8.2.6
Cooperative Learning
Analyze and discuss data
Present analysis to class

8.2.7-8.2.8
Draw diagrams of negative feedback mechanisms

Other Assessment

Journal Entries

Cooperative Learning

Concept Mapping

Suggested Learning Resources

Print

Texts

Biology: A Systems Approach
Chapter 10 - pages 310-313

Biology of Ourselves
Chapter 16 - pages 283-289

Biology: The Study of Life
Chapter 12 - pages 242-245

Nelson Biology
Chapter 9 - pages 205-212

Biological Science: An Ecological Approach
Chapter 16 - pages 444-448

Lab Activities

Biological Science: An Ecological Approach -
The Kidney and Homeostasis (page 445-447)
Nelson Biology -
Comparing Solutes in the Plasma, Nephron, and Urine (page 210)
Biology: A Systems Approach Lab Manual -
The Kidney (page 157)
The Nephron (page 163)
Biology: The Study of Life -
The Kidneys (page 248)

Multimedia

Prescribed Learning Outcomes

Topic 8.3: Disorders of The Urinary System

The student will be able to:

8.3.1 Describe how the following diseases/disorders affect the urinary system:
- diabetes mellitus
- diabetes insipidus
- nephritis
- kidney stones
- urinary tract infection

8.3.2 Explain the function of the kidney dialysis machine.

8.3.3 Identify urinary system disorders through urinalysis results.

Suggestions for Instruction

8.3.1-8.3.2

Research/Cooperative Learning Activity:
Have students work in groups and research one or all of the following topics:
- kidney dialysis
- diabetes mellitus
- diabetes insipidus
- nephritis
- kidney stones
- urinary tract infection

Students should report on their research and provide other students with written summaries of their findings.

8.3.3

Cooperative Learning/ Lab Activity:
Separate students into groups and perform a urinalysis lab. This may be accomplished with simulated urine samples. These supplies are available from biological supply houses. If supplies are not available, sample data could be provided and analyzed.

Suggestions for Assessment

Knowledge

8.3.1-8.3.3
Written test/quiz
Research Report
Oral Report
Identify disorders from urinalysis data

Skills and Processes

8.3.1-8.3.2
Research Activity
Participation in research/report
Presentation of report

8.3.3
Cooperative Learning Activity:
Participation inactivity
Analysis of data

Other Assessment

Journal Entries

Cooperative Learning

Concept Mapping

Suggested Learning Resources

Print

Texts

Biology: A Systems Approach
Chapter 10 - pages 313-314

Biology of Ourselves
Chapter 16 - pages 290-293

Biology: The Study of Life
Chapter 12 - page 245

Nelson Biology
Chapter 9 - pages 213-214

Biological Science: An Ecological Approach

Lab Activities

Nelson Biology -
Diagnosis of Kidney Disorders (page 216)
Nelson Biology -
Identification of Hyperglycemia (page 233)
Biology: The Study of Life Lab Manual
Urinalysis (pages 93-96)

Multimedia

Unit 9

Chemical Control

Overview

5 hours

Topics	Conceptual/Skill Development
9.1 **Hormones** 1 hour	• importance of hormones in maintaining homeostasis • one and two messenger models of hormone action • negative feedback mechanisms
9.2 **The Human Endocrine System** 2 hours	• identification of major endocrine glands • target sites, function, and control of major hormones secreted in the human body
9.3 **Disorders of the Endocrine System and Other Research Topics** 2 hours	• research activities • endocrine disorders • discovery of insulin • use of anabolic steroids • synthetic hormones

Prescribed Learning Outcomes

Topic 9.1: Hormones

The student will be able to:

9.1.1 Define the term hormone and endocrine gland.

9.1.2 Describe the importance of hormones in maintaining homeostasis within the human body.

9.1.3 Differentiate between steroid and protein/protein related hormones in terms of their controlling mechanisms.

9.1.4 Explain the regulation of hormone secretion through negative feedback mechanisms using examples.

9.1.5 Predict the effect of varying chemical stimuli on the secretion of endocrine glands.

Suggestions for Instruction

Entry Level Knowledge:
Students will not have studied the endocrine system in previous grades.

Teacher-led Discussion/Journal Entry:
Ask students about their knowledge of the endocrine system and/or hormones. Students can enter their responses in their journals. Students should make the connection to previous units where hormones were discussed, i.e. chemistry of life (lipids-anabolic steroids), the digestive system(secretin, gastrin), circulatory system(adrenaline, noradrenaline), and excretory system(ADH, aldosterone).

9.1.1-9.1.3
Define hormone and endocrine gland. Emphasize that the endocrine system, along with the nervous system is one of the most important systems for maintaining homeostasis in the body. Discuss hormones and the various functions they perform in the body, i.e. regulating growth, reproduction and development, blood sugar/solute levels, behaviour, digestion.
Differentiate between steroid and protein/protein related hormones. Discuss the different mechanisms of control related to these types of hormones, i.e. one-messenger and two-messenger models. Give examples of each of these types of hormones Have students draw or label diagrams illustrating the action of these two different types of hormones.

9.1.4-9.1.5
Teacher-led Discussion/Student Activity:
You may wish to cover these outcomes within the context of studying specific hormone action in the next topic. Discuss the process of negative feedback with students. Relate this process to the regulation of temperature by a thermostat. Many different endocrine examples could be used to illustrate this process, e.g. the regulation of thyroxine by the hypothalamus. Provide students with different scenarios and have them predict the resulting endocrine gland effect. e.g. How does drinking water affect the release of ADH from the pituitary gland? How is the secretion of TSH by the pituitary gland affected by increased levels of thyroxine in the blood?

Suggestions for Assessment

Knowledge

9.1.1-9.1.5
Written test/quiz
Differentiate between steroid and protein hormone action
Present hypothetical situations involving negative feedback situations.

Skills and Processes

9.1.5
Negative feedback predictions

9.1.1-9.1.5
Discussion/Journal Activity
Participation in Discussion
Journal Entries

Other Assessment

Journal Entries

Concept Mapping

Suggested Learning Resources

Print

Texts

Biology: A Systems Approach
Chapter 12 - pages 349-350, 355-356

Biology of Ourselves

Biology: The Study of Life
Chapter 16 - pages 313-319

Nelson Biology
Chapter 10 - pages 222-226

Biological Science: An Ecological Approach
Chapter 17 - pages 469-480

Laboratory Activities

Biology: The Study of Life - *Negative Feedback* (page 329)

Multimedia

Prescribed Learning Outcomes

Topic 9.2: The Human Endocrine System

The student will be able to:

9.2.1 Identify the location of the following major endocrine glands/organs of the human body from a diagram or model:

- hypothalamus
- thyroid
- adrenal
- ovaries (female)
- stomach
- pituitary
- parathyroid
- pancreas
- testes (male)
- small intestine

9.2.2 List the target site(s), major function(s) endocrine gland origin and factor(s) controlling release for the following hormones:

- thyroid-stimulating hormone (TSH)
- adrenocorticotrophic hormone (ACTH)
- somatotropic (growth) hormone (STH)
- follicle stimulating hormone (FSH)
- luteinizing hormone (LH)
- prolactin
- oxytocin
- antidiuretic hormone(vasopressin) (ADH)
- thyroxine
- calcitonin
- parathormone
- glucocorticoids
- mineralcorticoids
- adrenaline (epinephrine)
- noradrenaline (norepinephrine)
- glucocorticoids (cortisol)
- mineralcorticoids (aldosterone)
- insulin
- glucagon
- estrogen
- progesterone
- testosterone
- gastrin
- secretin

9.2.3 Explain why the pituitary gland is referred to as the "master gland".

9.2.4 Describe how the hypothalamus controls the secretions of the pituitary gland.

Suggestions for Instruction

9.2.1-9.2.2

Cooperative Learning Activity:
Separate students into groups of two or three and have them work on the following activities:

Examine some photos of various endocrine system disorders such as giantism, dwarfism, acromegaly, goiter, cretinism, etc. to stimulate interest in endocrine system function.

Hand out a diagram of the human body outlining the major endocrine organs. Have students label the diagram.

Have students create a chart listing the major endocrine glands identified above. Include in this chart columns entitled target site(s), function(s) and factor(s) controlling secretion. You may want to include columns entitled hypersecretion and hyposecretion as well. Have students fill in this chart based on information provided by the teacher or based on research. Review the results as a group.

NOTE: You should discuss the specific action of the sex hormones in the context of the reproductive system. The hormones affecting the digestive system, circulatory system and excretory system should have been studied in previous units.

9.2.3-9.2.4

Emphasize the role of the pituitary gland as the "master gland" due to the fact that it controls the secretion of other endocrine glands. Explain the relationship between the pituitary gland and the hypothalamus, including the role of releasing factors in controlling the anterior pituitary gland.

Cooperative Learning/ Laboratory Activity:
If time allows, there are a number of labs which could be performed by students that study endocrine function. Some of these are listed on the following page.

Suggestions for Assessment

Knowledge

9.2.1-9.2.4
Written test/quiz
Label diagram showing location of endocrine glands.
Fill in chart outlining major endocrine glands, hormone(s) secreted, target site(s), factor(s) controlling release and function(s).

Skills and Processes

9.2.1-9.2.2
Participation in Cooperative Learning Activity

Other Assessment

Journal Writing

Concept Mapping

Suggested Learning Resources

Print

Texts

Biology: A Systems Approach
Chapter 12 - pages 361-372

Biology of Ourselves
Chapter 3 - pages 102-103

Biology: The Study of Life
Chapter 16 - pages 314, 319-328

Nelson Biology
Chapter 10 - pages 226-237

Biological Science: An Ecological Approach
Chapter 17 - pages 469-480

Laboratory Activities

Biological Science: An Ecological Approach - *A Bike Trip* (page 472-475)
Nelson Biology - *Identification of Hyperglycemia* (page 233)
Nelson Biology - Case Study *The Effects of Hormones on Blood Sugar* (p. 233)
Biology: The Study of Life - *Effects of Chemicals on Heart Rate in Daphnia* (page 330)
Biology: The Study of Life Lab Manual *Regulation: Chemical Control* (page 121)

Multimedia

Prescribed Learning Outcomes

Topic 9.3: Disorders of the Endocrine System and Other Research Topics

The student will be able to:

9.3.1 Describe the cause, symptoms, and treatment of the disorders related to the following hormones:
- STH (giantism, acromegaly, dwarfism)
- aldosterone (Cushing's disease, Addison's disease
- thyroxine (hyperthyroidism, goiter, hypothyroidism, cretinism)
- insulin (hypoglycemia, hyperglycemia, diabetes mellitus

9.3.2 Discuss the contribution of Frederick Banting and Charles Best to the knowledge about endocrine system function.

9.3.3 Discuss the effects of anabolic steroid use on the human body.

9.3.4 Discuss the use of hormones in animal farming.

Suggestions for Instruction

9.3.1-9.3.4

Research/Cooperative Learning Activity:
Have students work in groups and research one of the following topics related to endocrine function:
- endocrine system disorders:
  a) STH (giantism, acromegaly, dwarfism)
  b) aldosterone (Cushing's disease, Addison's disease
  c) thyroxine (hyperthyroidism, goiter, hypothyroidism, cretinism)
  d) insulin (hypoglycemia, diabetes mellitus)
- discovery of insulin
- use of hormones in animal farming
- use of anabolic steroids in athletes
- advancements in treatment of diabetes

Students should report on their research and provide other students with written summaries of their findings.

Suggestions for Assessment

Knowledge

9.3.1-9.3.4
Research Report - Oral/Written
Present student with hypothetical situations involving disorders.

Skills and Processes

9.3.1-9.3.4
Research Report
Oral/Written
Research skills

Other Assessment

Cooperative Learning

Journal Writing

Suggested Learning Resources

Print

Texts

Biology: A Systems Approach
Chapter 12 - pages 361-372

Biology of Ourselves
Chapter 3 - pages 102-103

Biology: The Study of Life
Chapter 16 - pages 314, 319-328

Nelson Biology
Chapter 10 - pages 226-237

Biological Science: An Ecological Approach
Chapter 17 - pages 469-480

Multimedia

Unit 10

Nervous Control

Overview
12 hours

Topics	Conceptual/Skill Development
10.1 **Coordination and Regulation** .5 hour	• functions of the nervous system • define stimulus, receptor, impulse, effector • the role of the nervous system in homeostasis
10.2 **The Neuron** 2.5 hours	• types of nerves and neurons • structure and function of the parts of a neuron • transmission of a nerve impulse • the synapse-(effects of psychoactive drugs, neurotoxins) • demonstrate some human reflexes/measure reaction time
10.3 **The Nervous System** 1.5 hour	• structure and function of the central nervous system • brain anatomy (sheep brain dissection) • the autonomic vs. the somatic nervous system • sympathetic and parasympathetic nervous system
10.4 **Brain Function** 3 hours	• mental processes, brain mapping • behavior (reflexive, instinctive, and learned) • memory and learning • perception
10.5 **Sensory Receptors** 2.5 hours	• types of sensory receptors in humans • structure and function of the eye • structure and function of the ear • the senses of taste and smell • activities investigating senses
10.6 **Disorders of the Nervous System** 2 hours	• research activities • multiple sclerosis, Huntington's chorea, Parkinson's disease, Alzheimer's disease, epilepsy, cerebral palsy, dyslexia, meningitis, glaucoma, cataracts, astigmatism, myopia, hyperopia, color blindness, deafness

Prescribed Learning Outcomes

Topic 10.1: Coordination and Regulation

The student will be able to:

10.1.1 List the main functions of the nervous system, i.e. receive, coordinate, and respond to information.

10.1.2 Differentiate between the terms stimulus, receptor, impulse, and effector.

10.1.3 Describe the importance of the nervous system in maintaining homeostasis within the human body.

Suggestions for Instruction

Entry Level Knowledge:
Students will not have studied the nervous system in previous grades.

Teacher-led Discussion/Journal Entry:
Ask students about their knowledge of the nervous system. What is the function of the nervous system? What would they like to learn from this unit? Students can enter their responses in their journals. Make the connections between the nervous system and previous units of study e.g. the regulation of the pituitary gland by the hypothalamus, the control of heartrate, the release of saliva from the salivary glands, etc.
Have students begin a concept map of the nervous system.

10.1.1-10.1.3
Summarize the major functions of the nervous with students. Highlight the importance of coordination and regulation in those functions, emphasizing that the nervous system, along with the endocrine system is responsible for maintaining homeostasis in the body.

Define the terms stimulus, receptor, impulse, and effector and how they relate to each other.

Cooperative Learning Activity:
Present groups of students with some hypothetical situations where the body needs to respond to change. See if students can determine whether the endocrine system or nervous system (or both) is required. Typically, the nervous system responds rapidly to environmental changes, whereas the endocrine system provides long term sustained adjustments.

If time allows, you could have students perform a lab activity where they view an organism's response to stimuli.

Suggestions for Assessment

Knowledge

10.1.1-10.1.3
Written test/quiz
Define the terms stimulus, receptor, impulse, and effector using examples
Explain the importance of the nervous system in maintaining homeostasis.

Skills and Processes

10.1.1-10.1.3
Discussion/Journal Activity
Participation in Discussion
Journal Entries
Cooperative Learning Activity

Other Assessment

Journal Entries

Concept Mapping

Cooperative Learning

Suggested Learning Resources

Print

Texts

Biology: A Systems Approach
Chapter 13 - pages 377-378

Biology of Ourselves
Chapter 3 - page 84

Biology: The Study of Life
Chapter 14 - pages 271-272

Nelson Biology
Chapter 11 - pages 240-241

Biological Science: An Ecological Approach
Chapter 17 - pages 461-463

Laboratory Activities

Biological Science: An Ecological Approach - *A Sensory Receptors and Response to Stimuli* (pages 461-463)
Biology: The Study of Life
Observing the Behavior of Planarians (page 284)
Biology: The Study of Life Lab Manual
Observing Responses to Stimuli (page 103)

Multimedia

Prescribed Learning Outcomes

Topic 10.2: The Neuron

The student will be able to:

10.2.1 Describe the function of a neuron.

10.2.2 Identify from a diagram or model the following structures of a neuron:
- cell body
- dendrites
- axon
- Schwann cells (myelin)
- node(s) of Ranvier
- neurilemma

10.2.3 Describe the function of the structures in 10.2.2.

10.2.4 Differentiate between sensory, motor, and interneurons and sensory, motor, and mixed nerves.

10.2.5 Illustrate and explain the function of a reflex arc using an example.

10.2.6 Demonstrate some human reflexes and measure reaction rates.

10.2.7 Explain how a nerve impulse is transmitted through a neuron using the following terms:
- resting potential (polarization)
- sodium-potassium pump
- action potential
- refractory period
- threshold
- all-or-none response

10.2.8 Explain how the nervous system distinguishes between stimuli of different types and strengths.

10.2.9 Describe the transmission of a nerve impulse across a synapse.

10.2.10 Discuss the effects of psychoactive drugs and neurotoxins on synaptic transmission.

Suggestions for Instruction

10.2.1-10.2.5

Teacher-led Discussion/Student Activity:
Identify the neuron as the basic unit of structure and function of the nervous system. Hand out a blank diagram of a neuron and have students label the parts. Discuss the function of each of these component parts. Point out that impulses will travel in only one direction.
Discuss the fact that not all neurons are identical, although all neurons are made up of the same 3 main components (dendrites, cell body, axon). The specific structure of the neuron depends upon its location and function.
Differentiate between sensory, motor, and interneurons in terms of their function as well as the differences between sensory, motor, and mixed nerves. Relate this discussion to a reflex arc, the simplest nerve pathway.
Have students observe prepared slides, electron micrographs, or photographs of nerves to illustrate the orientation of the axons.

10.2.5-10.2.6

Cooperative Learning/Laboratory Activity:
Separate students into pairs, alternating as subjects and experimenters. Have them demonstrate some human reflexes and measure reaction rates. Some possible human reflexes to measure include: Knee-jerk, Achilles reflex, Babinski reflex, Pupillary reflex. Reaction times may be measured with a ruler or meter stick.

10.2.7-10.2.10

Teacher-led Discussion:
Illustrate the electrical state of a resting neuron and define the term polarization. Show students how the nerve impulse travels along the neuron as a result of electro-chemical changes. Discuss the role of the sodium-potassium pump and terms such as action potential, refractory period, threshold, and all-or-none response.
Explain how the nervous system distinguishes between stimuli of different types and strengths.
Illustrate the structure of a synapse, the transmission of a nerve impulse across the synaptic cleft,and the role of neurotransmitters.
Discuss how different psychoactive drugs and neurotoxins effect the ability of neurotransmitters to perform their function, e.g. nerve gas, botulin, valium, LSD, etc.

Suggestions for Assessment

Knowledge

10.2.1-10.2.10
Written test/Quiz
Label or draw diagram of a neuron
Draw diagrams to explain the reflex arc, transmission of a nerve impulse, and synaptic transmission.

Skills and Processes

10.2.5-10.2.6
Participation in cooperative groups
Performance test
Demonstration of reflexes
Measurement of reaction time

Other Assessment

Journal Entries

Concept Mapping

Cooperative Learning

Suggested Learning Resources

Print

Texts

Biology: A Systems Approach
Chapter 13 - pages 378-384, 388-390

Biology of Ourselves
Chapter 3 - pages 84-87, 97-98

Biology: The Study of Life
Chapter 14, 15 - pages 273-281, 297-299

Nelson Biology
Chapter 11 - pages 241-254

Biological Science: An Ecological Approach
Chapter 17 - pages 463-465

Laboratory Activities

Nelson Biology -
Reflex Arcs and Reaction Time (page 245-246)
Biology: The Study of Life Lab Manual
Testing Reflexes and Reactions (page 111)
Biology of Ourselves -
Human Reflexes (pages 97-98)
Biology: A Systems Approach Lab Manual -
Reflex Action (page 183)

Multimedia

Prescribed Learning Outcomes

Topic 10.3: The Nervous System

The student will be able to:

10.3.1 Differentiate between the central nervous system and the peripheral nervous system.

10.3.2 Describe the functions of the following structures of the central nervous system:
- brain
- spinal cord
- meninges
- cerebrospinal fluid.
- gray matter
- white matter

10.3.3 Identify from a model, specimen, or diagram and describe the functions for the following parts of the brain:
- cerebrum (and related lobes - frontal, temporal, parietal, occipital)
- cerebellum
- corpus callosum
- medulla oblongata
- pons
- thalamus
- hypothalamus
- pituitary gland

10.3.4 Differentiate between the autonomic and somatic nervous systems.

10.3.5 Explain how the sympathetic and parasympathetic divisions of the autonomic nervous system contribute to homeostasis.

Suggestions for Instruction

10.3.1-10.3.2
Teacher-led Discussion/Student Activity:
Differentiate between the central and peripheral nervous systems. Discuss the major components of the central nervous system, highlighting the function of the brain, spinal cord, meninges, cerebrospinal fluid, gray matter and white matter.

10.3.3
Laboratory Activity/Teacher Demonstration:
Have students work in groups and dissect a sheep brain or perform a demonstration of this activity for students. Identify the major structures and describe the function(s) of those structures. Have students draw a diagram or label a blank diagram of the structures identified.

10.3.4-10.3.5
Teacher-led Discussion:
Discuss the difference between the somatic (voluntary) and autonomic (involuntary) nervous systems. Emphasize the role of the autonomic nervous system in maintaining homeostasis. Discuss the antagonistic roles of the sympathetic and parasympathetic nervous systems. Provide students with diagrams and charts outlining the sympathetic and parasympathetic nervous systems and their functions.

Suggestions for Assessment

Knowledge

10.3.1-10.3.8
Written test/Quiz
Label diagram of the CNS and brain
Explain the antagonistic roles of the sympathetic and parasympathetic nervous systems in maintaining homeostasis

Skills and Processes

10.3.2
Performance test
Identification of brain parts
Draw diagram

Other Assessment

Journal Entries

Concept Mapping

Cooperative Learning

Suggested Learning Resources

Print

Texts

Biology: A Systems Approach
Chapter 13 - pages 391-400

Biology of Ourselves
Chapter 3 - pages 87-101

Biology: The Study of Life
Chapter 15 - pages 289-298

Nelson Biology
Chapter 11 - pages 256-261

Biological Science: An Ecological Approach
Chapter 17 - pages 464-469

Laboratory Activities

Biology of Ourselves -
Dissection of a Sheep Brain (pages 94-95)
Biology: A Systems Approach Lab Manual -
The Brain (page 187)

Multimedia

Prescribed Learning Outcomes

Topic 10.4: Brain Function

The student will be able to:

10.4.1 Speculate from several different perspectives on the nature of mental processes and the mind-brain dilemma.

10.4.2 Explain what is meant by referring to the brain as a "black box".

10.4.3 Discuss how the brain is mapped by various means.

10.4.4 Distinguish between, list advantages and disadvantages, and give examples of reflexive, instinctive, and learned behaviour.

Suggestions for Instruction

10.4.1
Teacher-led Discussion/Journal Entry:
As an opening activity to the study of the brain, engage the class in a discussion aimed at making them aware of the mysteries of our thinking. The following are some questions that can be used to engage the class in reflecting about how the brain works. What is thinking? Where does thinking occur? Is all thinking in words? Students can enter their responses in their journals.

10.4.1-10.4.2
Cooperative Learning Activity:
Form groups of 3 or 4 students and have individuals in the groups engage in various problems-solving and thinking activities. Some possible problems might be mathematics story problems, thinking games such as chess or hearts, or assembling parts of something. While students engage in solving a problem, they report to the other students what they are thinking. Afterwards they compare their problem-solving methods.
Discuss problem-solving processes.
Engage class in speculation about the relationship between the mind and the brain. Can there be thought without a brain? What does it mean to be conscious? Are only humans conscious? Is a dog conscious? How do you know? A fly?
If possible, view video on brain function. Many excellent videos describing the thinking process and brain function are available.

10.4.3-10.4.4
Teacher-led Discussion:
Discuss methods of brain mapping with students and the valuable information it has provided about brain function.
Compare reflexes to instinctive and learned behaviours with the use of examples. Discuss advantages and disadvantages of each.

Student Activity:
Do an activity with class in which students are asked to raise their hand when you raise yours and pair with tapping of foot. Students will soon raise their hands when you tap your foot. This is an unconsciously learned behaviour.

Suggestions for Assessment

Knowledge

10.4.1-10.4.2
Written test/Quiz
Methods of brain mapping
Examples of learned, instinctive and reflexive behaviour.

Skills and Processes

10.4.1-10.4.5
Contributions of constructive ideas in class discussion.
Cooperative Learning Activity

Other Assessment

Journal Writing

Cooperative Learning

Concept Mapping

Suggested Learning Resources

Print

Texts

Biology: A Systems Approach
Chapters 13, 25 - pages 392-394, 715-722

Biology of Ourselves
Chapter 3 - pages 87-99, 107-111

Biology: The Study of Life
Chapters 15, 36 - pages 290-294, 792-800

Nelson Biology
Chapter 11 - pages 259-265

Biological Science: An Ecological Approach
Chapter 17 - page 466

Laboratory Activities

Biology of Ourselves -
A Conditioned Reflex (pages 98-99)

Multimedia

Prescribed Learning Outcomes

Topic 10.4: Brain Function
continued

The student will be able to:

10.4.5 Define and give examples of the terms cognitive and psychomotor as they relate to learning.

10.4.6 Differentiate between short-term and long-term memory.

10.4.7 Apply the principles of learning to personal learning.

10.4.8 Use memory-facilitating techniques to improve learning.

10.4.9 Distinguish between memory and perception.

10.4.10 Provide examples of perceptual ambiguity and perceptual distortion.

Suggestions for Instruction

10.4.5-10.4.6
Teacher-led Discussion:
Discuss the terms cognitive and psychomotor as they relate to learning. Use actual examples from this course to illustrate the differences.

Differentiate between short-term and long-term memory.

10.4.7-10.4.8
Cooperative Learning Activity:
Have class work in small groups to recall examples of ways they remember events, e.g. visual, verbal, etc. Use this information to plan how they will learn some biology material using the relationship between short and long term memory.
Develop a memory-facilitating technique for some biology principle or concept, e.g. mnemonic devices.

10.4.9-10.4.10
Teacher-led Discussion:
Distinguish between memory and perception

Cooperative Learning Activities:
Class activities with perceptual tests. Class and small group activities involving perception, e.g. faces, etc.

Suggestions for Assessment

Knowledge

10.4.5-10.4.10
Written test/Quiz
Test questions covering basic concepts and ideas
Provides examples of cognitive and psychomotor learning.
Differentiate between short-term and long-term memory.

Skills and Processes

10.4.5-10.4.10
Cooperative Learning Activities
Suggests ways to improve learning by using knowledge of short and long term memory.
Develop a memory-facilitating technique for some biology principle or concept,

Other Assessment

Journal Writing
Metacognition
Application of the principles of learning to personal learning

Suggested Learning Resources

Print

Texts

Biology: A Systems Approach
Chapters 25 - pages 722-723

Biology of Ourselves
Chapter 3 - pages 111-115

Biology: The Study of Life
Chapters 15, 36 - pages 293-294, 792-800

Nelson Biology

Biological Science: An Ecological Approach

Laboratory Activities

Biology of Ourselves -
Memory and Habit (page 112)
Sense and Nonsense (page 112)
Distractions and Learning (page 113)
Trial and Error Learning (page 114)
Organizing Information (page 114)
Seeing, Hearing and Touching: How Best to Learn (pages 114-115)
Biology: The Study of Life
Learning by Trial and Error (page 810)
Biology: A Systems Approach Lab Manual
Visual Perception (page 201)

Multimedia

Prescribed Learning Outcomes

Topic 10.5: Sensory Receptors

The student will be able to:

10.5.1 List and describe the stimulus detected for the different sensory receptors present in the human body.

10.5.2 Identify the following parts of the eye from a diagram, model, or specimen and describe their function:

- sclera
- choroid
- iris
- lens
- retina
- ciliary muscles
- cornea
- aqueous humor
- vitreous humor
- pupil
- optic nerve

10.5.3 Explain the process of vision in humans, including the role of rods and cones.

10.5.4 Identify the following parts of the ear from a diagram, model, or specimen and describe their function:

- pinna
- ossicles
- oval window
- vestibule
- cochlea
- auditory canal
- tympanic membrane
- eustachian tube
- semicircular canals
- auditory nerve

10.5.5 Describe the structure and function of the taste buds and olfactory cells.

Suggestions for Instruction

10.5.1-10.5.2

Teacher-led Discussion/Journal Activity:

Ask students to list in their journal all the types of information that their senses are responsible for detecting. Compile their responses on the board and discuss the type of receptor responsible for detecting that information. Discuss receptors studied in previous units, i.e. chemoreceptors(carotid artery) which detect CO_2 levels in the blood, osmoregulators (hypothalamus) which detect water concentration in the blood, pressure receptors which detect blood pressure, etc. List the types of receptors found in humans (i.e. mechanoreceptors (pressure, touch, stretch, motion), photoreceptors, chemoreceptors, thermoreceptors, pain receptors) and the type of stimulus detected by each . Use actual examples for each type. Emphasize that the sensory receptors allow the body to detect information from both the external and internal environments.

10.5.2-10.5.5

Teacher-led Discussion:

Hand out a diagram or present a model of the eye to students or dissect a cow eye. Identify the major structures and describe the function(s) of those structures. Have students draw a diagram or label a blank diagram of the structures identified. Discuss the process of vision with students, highlighting the role of rods and cones in this process.

Hand out a diagram or present a model of the ear to students. Discuss the structure and function of the major components, highlighting the two main functions of the ear, hearing and balance.

Discuss the structure and function of taste buds and olfactory cells, the structures responsible for our sense of taste and smell.

10.5.1-10.5.5

Cooperative Learning/Lab Activity:

There are a number of different labs and activities that students can perform related to the senses. You should pursue some of these, at least one which are available to you. They are listed on the next page. Students find most of these quite interesting.

Suggestions for Assessment

Knowledge

10.5.1-10.5.5
Written test/Quiz
Label diagrams of the eye and ear
Explain the functions of the sense receptors

Skills and Processes

10.5.1-10.5.5
Cooperative Learning
Performance test
Identification of sight perception, sense of touch, taste, smell.

Lab Report

Other Assessment

Journal Entries

Concept Mapping

Cooperative Learning

Suggested Learning Resources

Print

Texts

Biology: A Systems Approach
Chapter 14 - pages 405-407, 410-411, 414-418, 422-429

Biology of Ourselves
Chapter 4 - pages 120-150

Biology: The Study of Life
Chapter 15 - pages 299-307

Nelson Biology
Chapter 13 - pages 284-304

Biological Science: An Ecological Approach
Chapter 17 - pages 461-463, 467

Laboratory Activities

Biology of Ourselves -

Dissection of an Eye	(page 126)
Peripheral Vision	(page 127)
Discovery of the Blind Spot	(page 128)
The Pupillary Reflex	(page 129)
The Accommodation Reflex	(page 130)
The Snellen Eye Chart	(page 134)
Color Blindness	(page 135)
Near Point Accommodation	(page 135)
How Well do You Hear	(page 142)
The Romberg Test	(page 145)
The Sense of Taste	(page 145)
Taste vs. Smell	(page 147)
Two Point Discrimination Test	(page 148)
Other Skin Senses	(page 149)
Sensing Temperature	(page 150)

Biology: The Study of Life -
Investigation of Human Senses:: Sight (page 308)
Biology: The Study of Life Lab Manual
Investigating Senses: Sight , Touch and Taste (page 115)
Nelson Biology

Vision	(page 298)
Hearing and Equilibrium	(page 304)

Biology: A Systems Approach Lab Manual -
Perception of Touch, Temperature, Smell and Taste (page 193)

Prescribed Learning Outcomes

Topic 10.6: Disorders of the Nervous System

The student will be able to:

10.6.1 Describe the cause, symptoms, and treatment of five of the following disorders of the nervous system:
- multiple sclerosis
- Huntington's chorea
- Parkinson's disease
- Alzheimer's disease
- epilepsy
- cerebral palsy
- dyslexia
- meningitis
- glaucoma
- cataracts
- astigmatism
- myopia, hyperopia
- color blindness
- deafness
- motion sickness

Suggestions for Instruction

10.6.1

Research/Cooperative Learning Activity:
Have students work in groups and research one or more of the following topics/disorders related to the nervous system:
- multiple sclerosis
- Huntington's chorea
- Parkinson's disease
- Alzheimer's disease
- epilepsy
- cerebral palsy
- dyslexia
- meningitis
- glaucoma
- cataracts
- astigmatism
- myopia, hyperopia
- color blindness
- deafness
- motion sickness

Students should report on their research and provide other students with written summaries of their findings.

Suggestions for Assessment

Knowledge

10.6.1
Written test/quiz
Research Report
Oral Report

Skills and Processes

10.6.1
Research Activity
Participation in research/report
Presentation of report

Other Assessment

Journal Writing

Concept Mapping

Cooperative Learning

Suggested Learning Resources

Print

Texts

Biology: A Systems Approach
Chapters 13, 14 - pages 399, 426

Biology of Ourselves
Chapters 3, 4 - pages 92, 96, 132, 135, 141

Biology: The Study of Life
Chapter 15 - pages 212-213

Nelson Biology
Chapter 11, 12 - pages 254, 257, 296

Biological Science: An Ecological Approach

Multimedia

Unit 11

Support and Locomotion

Overview

7 hours

Topics	Conceptual/Skill Development
11.1 **The Skeletal System** 2 hours	• structure and function of bone and cartilage • identification of bone and cartilage from prepared slides • identification of major bones in humans • three types of joints • demonstration of movement in synovial joints
11.2 **The Muscular System** 1.5 hours	• structure and function of muscle types • identification of muscle types from prepared slides • tendons and ligaments • construct a model of skeletal muscle contraction
11.3 **The Musculoskeletal System** 2 hours	• importance of the coordination of the neuro-musculoskeletal system to movement. • musculoskeletal function (chicken wing dissection). • flexors and extensors as antagonistic pairs • nutrition and exercise for healthy bones and muscles
11.4 **Disorders of the Musculoskeletal System** 1.5 hours	• intrinsic and extrinsic factors affecting musculoskeletal system health • research activities • musculoskeletal disorders

Prescribed Learning Outcomes

Topic 11.1: The Skeletal System

The student will be able to:

11.1.1 Describe the structure and function of bone and cartilage in the the human musculoskeletal system.

11.1.2 Identify bone tissue and cartilage tissue from prepared microscope slides or electron micrographs.

11.1.3 Identify from a model, diagram, or specimen, the following components of the skeletal system:
- axial and appendicular skeleton
- skull (cranium, mandible)
- vertebral column
- pectoral girdle(clavicle, scapula)
- arm (humerus, ulna, radius, carpals, metacarpals, phalanges)
- rib cage and sternum
- pelvic girdle (pelvic bone)
- leg (femur, patella, tibia, fibula, tarsals, metatarsals, phalanges)
- four types of bones (long, short, flat, irregular)

11.1 4 Outline differences in the following human skeletons:
- male and female
- a baby and an adult.

11.1.5 Identify and describe the following types of joints in the human body:
- fibrous
- cartilaginous
- synovial

11.1.6 Demonstrate the functional movements of synovial joints (gliding, hinge, pivot, ball and socket).

Suggestions for Instruction

Entry Level Knowledge:
Students may have had exposure to the skeletal system in health classes. Teachers should review where necessary.

11.1.1
Teacher-led Discussion/Journal Activity:
Brainstorm with students regarding the function of bone and cartilage in body. .List possibilities on the board and eliminate misconceptions. Students can enter the revised list in their journals.

11.1.2
Teacher-led Discussion/Student Activity:
Discuss the composition of bone and cartilage with students, highlighting differences between the two as they relate to function. Have students observe and draw diagrams of bone and cartilage tissue from prepared microscope slides or electron micrographs. Label major structures in each.
You could obtain a leg bone or rib bone from a local butcher and view the structure as well as the attached cartilage.

11.1.3-11.1.4
Teacher-led Discussion/Student Activity:
Review anatomy and functions with a skeletal model and have students label their own diagrams. A table of data listing structure and function can also be compiled.
Outline differences between male and female skeletons as well as differences between baby and adult skeletons in humans. Discuss the process of ossification with students.

11.1.5 - 11.1.6
Cooperative Learning Activity:
Separate students into groups of two or three and have them prepare drawings of different types of joints as if they were on assignment as medical artists.
Students should be able to demonstrate the different types of movements of synovial joints using full skeletons models or other students. If time allows, have the students build one model of a joint of their choice in cooperative groups. Each group can present their model for later review to the class to discuss its merits, construction, design, etc.

Suggestions for Assessment

Knowledge

11.1.1-11-11.1.6
Written test/quiz
Label diagrams of skeletons, joints
Identification of bones, joints from models
Explain how structure is related to function
Describe differences in skeletons

Skills and Processes

11.1.1
Journal Writing
11.1.2
Diagrams of prepared slides
Observation of bone and cartilage structure
11.1.5-11.1.6
Drawings of joints
Demonstration of joint movement
Model building

Other Assessment

Journal Entries

Cooperative Learning Activities

Concept Mapping

Suggested Learning Resources

Print

Texts

Biology: A Systems Approach
Chapter 11 - pages 331-335

Biology of Ourselves
Chapter 2 - pages 40-64

Biology: The Study of Life
Chapter 13 - pages 259-262

Nelson Biology
Chapter 12 - pages 271-274

Biological Science: An Ecological Approach
Chapter 14 - pages 385-386

Laboratory Activities

Nelson Biology -
Bone Structure (page 273)
Biology of Ourselves -
Bone Structure (pages 41-42)
The Properties of Bone (pages 42-43
Biology: The Study of Life Lab Manual
Examining Muscle, Bone, and Cartilage
(page 97)

Multimedia

Prescribed Learning Outcomes

Topic 11.2: The Muscular System

The student will be able to:

11.2.1 Differentiate between skeletal, smooth, and cardiac muscle in terms of structure and function.

11.2.2 Identify skeletal, smooth, and cardiac muscle from prepared microscope slides or electron micrographs.

11.2.3 Differentiate between tendons and ligaments.

11.2.4 Construct a model to explain the contraction and relaxation of skeletal muscle outlining the following:
- the sliding filament theory
- the motor unit
- the source of energy for contraction
- the all-or-none principle of contraction.

11.2.5 Define the term muscle tone and explain why this condition is necessary.

Suggestions for Instruction

11.2.1
Teacher-led Discussion/Journal Activity:
Ask students to list and describe the function of the different types of muscle in their journals. They should respond with at least two of the three types based on their study of digestion and circulation.

11.2.2
Student Activity:
Have students observe and draw diagrams of skeletal, smooth, and cardiac muscle from prepared microscope slides or electron micrographs. Label major structures in each.

11.2.3
Teacher-led Discussion:
Discuss tendons and ligaments with students highlighting differences in terms of their function. You may wish to discuss sports related injuries to these structures at this time.

11.2.4-11.2.5
Teacher-led Discussion/Student Activity:
Present a series of diagrams or show a video to illustrate this process. The biochemical composition of skeletal muscle tissue should be introduced at this point. The connection between nervous and muscle tissue activity should be presented on a cause and effect basis. Have students construct their own model of skeletal muscle contraction.

Discuss the term muscle tone with students. Emphasize the need for this condition in order to maintain posture and readiness for movement.

Suggestions for Assessment

Knowledge

11.2.1-11.2.5
Written test/quiz
Label diagrams of muscle types
Explain the process of muscle contraction

Skills and Processes

11.2.1
Journal Writing
11.2.2
Diagrams of prepared slides
Observation of muscle tissue
11.2.4
Model of skeletal muscle contraction

Other Assessment

Journal Entries

Cooperative Learning Activities

Concept Mapping

Suggested Learning Resources

Print

Texts

Biology: A Systems Approach
Chapter 11 - pages 336-342

Biology of Ourselves
Chapter 2 - pages 65-70

Biology: The Study of Life
Chapter 13 - pages 263-265

Nelson Biology
Chapter 12 - pages 275-280

Biological Science: An Ecological Approach
Chapter 17 - pages 455-461

Laboratory Activities

Biology: The Study of Life Lab Manual
Examining Muscle, Bone, and Cartilage
(page 97)
Biology of Ourselves -
The Structure of Skeletal Muscle (page 68)
Nelson Biology -
Effect of Temperature on Muscle Contraction
(page 281)

Multimedia

Prescribed Learning Outcomes

Topic 11.3: The Musculoskeletal System

The student will be able to:

11.3.1 Describe the cooperative function of the neuro-musculoskeletal organization and it's importance to the functioning of the human body.

11.3.2 Illustrate the mode of action of muscle, tendon and ligament on bones and joints to produce body movements.

11.3.3 Differentiate between flexors and extensors in terms of their function as antagonistic pairs in moving parts of the skeleton.

11.3.4 Compare the action of antagonistic pairs of muscles to the mechanics of a simple lever.

11.3.5 Differentiate between muscle twitch, muscle fatigue, and muscle atrophy.

11.3.6 Discuss the benefits of regular exercise and good nutrition to:
- normal bone growth, replacement and ossification
- muscle activity

Suggestions for Instruction

11.3.1
Teacher-led Discussion/Journal Activity:
Have students describe in words or a flow chart their concept of the body components interacting to produce movement. Brainstorm with the class. Include the nervous system (brain, CNS, PNS), muscular and skeletal systems. Emphasize the cooperative functions of these systems.

11.3.2-11.3.4
Cooperative Learning/Laboratory Activity:
Separate students into groups of two or three. have them dissect a chicken wing. Identify muscle, bone, joints, tendons, and ligaments. Draw and label diagrams. Pull on the muscle groups and observe the results. Identify flexors and extensors as an antagonistic pair. Examine the elbow joint and observe it's operation. Make comparisons between the chicken wing and the human arm. Compare the muscle action observed to the mechanics of a simple lever. A lab report should be submitted.

11.3.5-11.3.6
Teacher-led Discussion/Journal Activity:
Differentiate between muscle twitch, muscle fatigue, and muscle atrophy.
Discuss conditions necessary for normal bone growth and replacement. List the events that take place overtime for bone ossification.

In a class discussion have students suggest ways in which regular exercise and nutrition might contribute to a healthy neuro-musculoskeletal system. You may want students to research this topic.

There are some interesting activities related to musculoskeletal function(*Biology of Ourselves, BSCS)* that students can perform themselves. These are shown on the next page.

Suggestions for Assessment

Knowledge

11.3.1-11.3.6
Written test/quiz
Comparisons of musculoskeletal movement to levers
Differentiate between muscle twitch, muscle fatigue, and muscle atrophy

Skills and Processes

11.3.2-11.3.4
Dissection of a chicken wing
Performance assessment
Lab Report

Other Assessment

Journal Entries

Cooperative Learning

Concept Mapping

Suggested Learning Resources

Print

Texts

Biology: A Systems Approach
Chapter 11 - pages 335-336, 340-341

Biology of Ourselves
Chapter 2 - pages 70-78

Biology: The Study of Life
Chapter 13 - pages 258-266

Nelson Biology
Chapter 272-281

Biological Science: An Ecological Approach
Chapter 17 - page 464

Laboratory Activities

Biology: The Study of Life Lab Manual
Anatomy of the Chicken Wing (page 266)
Biology of Ourselves -
A Look at Muscles and Tendons (page 72)
Tendons in Action (page 73)
Working Against Each Other (page 74)
Muscle Fatigue (page 76)
Reaction Times (page 76-77)
Biological Science: An Ecological Approach -
Muscles and Muscle Fatigue (page 457)

Multimedia

Prescribed Learning Outcomes

Topic 4: Diseases of the Musculoskeletal System

The student will be able to:

11.4.1 List five extrinsic and intrinsic factors that could affect the health of the musculoskeletal system.

11.4.2 Outline the symptoms, diagnosis, prevention of five of the following musculoskeletal problems:
- osteoporosis
- slipped disc
- curvatures
- spina bifida
- rheumatism
- arthritis
- bursitis
- dislocation
- sprain
- tendonitis
- muscular dystrophy
- multiple sclerosis
- atrophy
- hypertrophy

Suggestions for Instruction

11.4.1
Teacher-led Discussion:
Brainstorm with students for the list.
(1) environment
(2) heredity
(3) disease (microbial)
(4) ageing
(5) nutrition
(6) lifestyle
(7) deterioration repair and immune systems
(8) accident, etc.

11.4.2
Cooperative Learning/Research Activity:
Divide students into groups to research the following disorders:
- osteoporosis
- slipped disc
- curvatures
- spina bifida
- rheumatism
- arthritis
- bursitis
- dislocation
- sprain
- tendonitis
- muscular dystrophy
- multiple sclerosis
- atrophy
- hypertrophy

Cooperative groups can research and present their findings. Students should prepare a research presentation outlining symptoms, diagnosis, medical applications such as arthroscopy and the action of selected drugs associated with articulations, prevention, prognosis, impact on movement. Classify these into the established list for 11.4.1. Encourage students to prepare their own videos, interview patients, visit doctors for old x-rays. Excellent videos are now available on these disorders for class review.

Suggestions for Assessment

Knowledge

11.4.1-11.4.2
Written test/quiz
Research Report
Oral Report

Skills and Processes

111.4.1-11.4.2
Research Activity
Participation in research/report
Presentation of report

Other Assessment

Journal Writing

Concept Mapping

Cooperative Learning

Suggested Learning Resources

Print

Texts

Biology: A Systems Approach
Chapter 11

Biology of Ourselves
Chapter 2

Biology: The Study of Life
Chapter 13

Nelson Biology
Chapter 12

Biological Science: An Ecological Approach
Chapter 17

Multimedia

Unit 12

Reproduction and Development

Overview

12 hours

Topics	Conceptual/Skill Development
12.1 **Meiosis and Gametogenesis** 3 hours	• importance of sexual reproduction to the human species • activity simulating meiosis • spermatogenesis and oogenesis • observation of prepared slides of testes and ovaries • potential problems during gametogenesis
12.2 **Human Reproduction** 4 hours	• structure and function of the male reproductive system • structure and function of the female reproductive system • menstrual cycle • birth control/fertility issues • sexually transmitted diseases
12.3 **Human Embryonic Development** 3 hours	• fertilization and formation of the zygote • cleavage and gastrulation (3 germ layers) • development in the three trimesters • hormonal changes resulting from pregnancy and birth • research into congenital abnormalities
12.4 **Aging** 2 hour	• developmental changes in humans (class discussion) • the process of aging • factors which accelerate or slow the aging process • research activities

Prescribed Learning Outcomes

Topic 12.1: Meiosis and Gametogenesis

The student will be able to:

12.1.1 Explain why the survival of the human species depends on the existence of a mechanism of sexual reproduction.

12.1.2 Describe the role of meiosis (reduction division) in the production of germ cells (gametes) in humans.

12.1.3 Illustrate and describe the events of meiosis in a "typical" cell including the following:
- homologous pairs of chromosomes
- crossing-over
- haploid cell
- diploid cell
- meiosis I
- meiosis II

12.1.4 Compare and contrast the processes of spermatogenesis and oogenesis in humans.

12.1.5 Identify the following structures on a prepared microscope slide of a testis:
- primary spermatocyte
- secondary spermatocyte
- spermatids
- spermatozoa

12.1.6 Identify the following structures on a prepared microscope slide of the ovary:
- primary oocyte
- ovum (egg cell)
- polar bodies
- follicle
- corpus luteum

12.1.7 Discuss potential problems that may occur during human gametogenesis, e.g. too many or too few cells produced, poor genetic quality, poor motility of sperm cells, inability to ovulate.

Suggestions for Instruction

Entry Level Knowledge:
Students will have studied the human reproductive system in Senior 1. Teachers should review where necessary.

12.1.1-12.1.2
Teacher-led Discussion/Journal Entry:
Ask students the following questions: Why is the reproductive system important to human beings? What would they like to learn from this unit? Students can enter their responses in their journals. Discuss the answers to these questions with students. Emphasize that sexual reproduction allows genetic recombination, thus adaptability to changing environmental conditions.
Briefly review the process of mitosis studied in Senior 2. Discuss the terms haploid and diploid. Emphasize that recombination of genetic material in sexual reproduction results in the maintenance of the correct diploid chromosome number at 46; thus a "reduction division" is necessary in the "sex cells".

12.1.3
Cooperative Learning Activity:
Separate students into groups and have them perform an activity which simulates meiosis. Use "pop-bead" kits, colored pipe cleaners, modeling clay, or yarn to illustrate the events of meiosis. The contrasting colours allow the illustration of crossing over in Meiosis I.

12.1.4-12.1.6
Teacher-led Discussion/Student Lab Activity:
Differentiate between the processes of spermatogenesis and oogenesis. Emphasize the high degree of cellular variation as opposed to the model cell they did in the previous activity. Have students view and draw diagrams of prepared slides of human testes and ovaries. Label identifiable structures.

12.1.7
Teacher-led Discussion/Research Activity:
A class discussion on these problems might be interesting, or a research project could be used here. One might want to discuss the ethics of "bypassing" reproductive problems with the new, available technologies.

Suggestions for Assessment

Knowledge

12.1.1-12.1.7
Written test/quiz
Explain why the survival of the human species depends on the existence of a mechanism of sexual reproduction.
Label diagrams and explain meiosis, gametogenesis.
Identify potential problems with gametogenesis.

Skills and Processes

12.1.1-12.1.2
Discussion/Journal Activity:
Participation in Discussion
Journal Entries
12.1.3
Cooperative Learning Activity:
Model building - meiosis
12.1.5-12.1.6
Lab Activity:
Identification of testes and ovaries and related structures
12.1.7
Class Discussion
Research

Other Assessment

Journal Entries

Concept Mapping

Cooperative Learning

Suggested Learning Resources

Print

Texts

Biology: A Systems Approach
Chapter 16 - pages 464-470

Biology of Ourselves
Chapter 10 - pages 302-305

Biology: The Study of Life
Chapter 21 - pages 417-422, 429-430

Nelson Biology
Chapter 23 - pages 550-558

Biological Science: An Ecological Approach
Chapter 6 - pages 139-147

Laboratory Activities

Biology: The Study of Life
Chromosome Movements During Meiosis (page 423)
Mammalian Gonads and Gametes (page 468)
Biology: The Study of Life Lab Manual
Simulating Meiosis (page 161)
Nelson Biology -
Comparing Meiosis and Mitosis (page 556)
Microscopic View of the Testes (page 514)
Biology of Ourselves -
Examination of Reproductive Tissues and Cells (page 332))
Biological Science: An Ecological Approach -
A Model of Meiosis (page 144-146)

Multimedia

Prescribed Learning Outcomes

Topic 12.2: Human Reproductive System

The student will be able to:

12.2.1 Explain why humans need a system of internal reproduction.

12.2.2 Identify from a diagram or model and describe the function of the following structures of the human male reproductive system:
- vas deferens
- urethra
- penis
- epididymis
- testis
- scrotum
- seminal vesicle
- prostate gland
- bulbourethra (Cowper's) gland

12.2.3 Describe the influence of the hormones FSH and LH on the function of the testis.

12.2.4 Describe the role and regulation of testosterone in humans.

12.2.5 Identify from a diagram or model and describe the function of the following structures of the human female reproductive system:
- ovary
- oviduct
- uterus
- cervix
- vagina
- labia

12.2.6 Describe the menstrual cycle in females including the role of the following hormones:
- FSH
- LH
- estrogen
- progesterone

12.2.7 Compare the effectiveness of several methods of birth control, i.e. barrier, rhythm, hormonal, implantation prevention, surgical.

12.2.8 Describe the cause and symptoms of the following sexually transmitted diseases: AIDS, genital herpes, genital warts, gonorrhea, chlamydia, and syphilis.

12.2.9 Discuss the biotechnology/bioethics related to in-vitro fertilization or surrogate mothers

Suggestions for Instruction

12.2.1
Teacher-led Discussion:
A general discussion on reproduction in various organisms might help to place the human species in context, re the need for an internal mechanism and copulation. You could include a discussion of sexuality here, in the context of mate selection and sexual recombination.

12.2.2-12.2.4
Teacher-led Discussion:
Use slides, diagrams, models, etc. of male reproductive system to ensure that students have a good understanding of the anatomy. You may wish to have students label a blank diagram. If available, a frozen sperm sample from an agricultural artificial insemination operation could be examined.
Discuss the role of testosterone in controlling spermatogenesis and the development of secondary sex characteristics.

12.2.5-12.2.6
Teacher-led Discussion/Cooperative Learning:
Use slides, diagrams, models, etc. of the female reproductive system to ensure that students have a good understanding of the anatomy. You may wish to have students label a blank diagram.
Discuss the menstrual cycle, outlining it's cyclic nature and the hormonal control over it. This hormonal interplay is complicated. Thus, diagrams and charts should be used to explain this to students.
Some good cooperative learning activities related to the study of the menstrual cycle can be used here.

12.2.7-12.2.9
Cooperative Learning/Research Activity:
Separate students into groups to research these topics and have each group report back to the class. Each group should provide an oral report and a written synopsis for other students.
Class Debate:
A class debate on the use of birth control, in-vitro fertilization or surrogate motherhood would be interesting.

Suggestions for Assessment

Knowledge
12.2.1-12.2.9
Written test/quiz
Identification of male and female reproductive structures.
Explanation of the events of the menstrual cycle.
Birth Control Methods
STD's
Sterility
12.2.7-12.2.9
Research Activity:
Written/oral report

Skills and Processes
12.2.1
Discussion:
Participation in Discussion
12.2.5-12.2.6
Cooperative Learning Activity:
Menstrual Cycle
12.2.7-12.2.9
Research Activity:
Written/oral report
Class Debate

Other Assessment
Journal Entries

Concept Mapping

Cooperative Learning

Suggested Learning Resources

Print

Texts
Biology: A Systems Approach
Chapters 12, 18 - pages 367-369, 504-506

Biology of Ourselves
Chapter 11 - pages 326-337, 347-355

Biology: The Study of Life
Chapter 23 - pages 457-462

Nelson Biology
Chapter 21 - pages 508-522

Biological Science: An Ecological Approach
Chapter 6 - pages 146-151

Laboratory Activities
Biology: The Study of Life Lab Manual
The Human Menstrual Cycle (page 173)
Nelson Biology -
Hormone Levels During the Menstrual Cycle (page 521)

Multimedia

Prescribed Learning Outcomes

Topic 12.3: Human Embryonic Development

The student will be able to:

12.3.1 Describe the process of fertilization in humans including the changes which occur in the sperm and egg.

12.3.2 Describe the main characteristics of cleavage and gastrulation in an early human embryo.

12.3.3 List the three germ layers of the human embryo and give an example of a tissue type that arises from each.

12.3.4 Explain what is meant by the implantation of an embryo and how this changes the hormonal and cyclic events of the uterus and ovary.

12.3.5 Identify from a diagram or model and describe the function of the following structures of a human embryo:
- chorion
- amnion
- placenta
- allantois
- yolk sac
- umbilical cord

12.3.6 Summarize the major changes which occur in each of the three trimesters of embryonic development in humans.

12.3.7 Describe the physical and hormonal changes which occur in the mother during and immediately following the birth process.

12.3.8 Describe the effect of environmental factors which are suspected in leading to congenital abnormalities, e.g. alcohol, smoking, drugs, rubella, AIDS, radiation, diet etc.

12.3.9 Discuss the following methods prenatal diagnosis in terms of accuracy and risk:
- ultrasound
- amniocentesis
- chorionic villi sampling

Suggestions for Instruction

12.3.1-12.3.7

Teacher-led Discussion:

Discuss the process of fertilization in humans. Outline the changes which occur in the sperm and egg, resulting in the formation of the zygote. Stress that fertilization is the trigger for developmental changes leading to the proper development of the fetus.

Discuss the fact that cleavage is mitosis without any cytoplasmic growth leading to a hollow ball of cells. Gastrulation is the folding of the embryo into three germ layers: ectoderm (skin, nerves, teeth) mesoderm (muscles, kidney and reproductive organs) and endoderm (digestive tract, liver, and pancreas).

Outline the process of implantation (pregnancy) and the resulting hormonal changes which occur in the mother in order to maintain the corpus luteum. You may wish to discuss ectopic pregnancies here as well and some the problems associated with them.

Emphasize the first month of development, in which the germ layers, extra-embryonic membranes and placenta are established.

Present a diagram or model of an embryo to students and point out the extra-embryonic membranes, placenta, and umbilical cord. Discuss the function of these structures.

You may wish to study the structure of a chicken egg and make comparisons to a human embryo.

Summarize the major changes which occur in each of the three trimesters of embryonic development in humans. You may wish to present this in the form of a chart for students.

Discuss the physical and hormonal changes (oxytocin, relaxin, prolactin) which occur in the mother during and immediately following the birth process.

12.3.8-12.3.9

Cooperative Learning/Research Activity:

Separate students into groups to research these topics and have each group report back to the class. Each group should provide an oral report and a written synopsis for other students.

Class Debate:

Structure a class debate on the use of tobacco, alcohol, caffeine or any other drugs during pregnancy.

Suggestions for Assessment

Knowledge

12.3.1-12.3.9
Written test/quiz
- Describe fertilization, implantation, cleavage, gastrulation.
- Identify three germ layers and the tissue types they give rise to
- Summarize the developmental changes in the fetus in the three trimesters
- Label diagram of embryo
- Discuss hormonal changes related to pregnancy and birth

12.3.8-12.3.9
Research Activity:
- Written/oral report

Skills and Processes

12.3.8-12.3.9
Research Activity:
- Written/oral report
- Class Debate

Other Assessment

Journal Entries

Concept Mapping

Cooperative Learning

Suggested Learning Resources

Print

Texts

Biology: A Systems Approach
Chapter 18 - pages 506-515

Biology of Ourselves
Chapter 11 - pages 337-347

Biology: The Study of Life
Chapter 23 - pages 463-467

Nelson Biology
Chapter 21 - pages 522-527

Biological Science: An Ecological Approach
Chapter 7 - pages 166-170

Laboratory Activities

Biology: The Study of Life Lab Manual
Development of Chick Embryos (page 167)
Nelson Biology -
Hormone Levels During the Menstrual Cycle (page 521)

Multimedia

Prescribed Learning Outcomes

Topic 12.4: Aging

The student will be able to:

12.4.1 Outline the developmental changes in humans from the fetus to the adult.

12.4.2 Define the term aging.

12.4.3 Describe at least two factors that contribute to the aging process; ie genetic causes, deterioration of cellular repair, whole body deterioration in immune system, extrinsic factors (injury, environmental factors).

Suggestions for Instruction

12.4.1-12.4.3

Class Discussion/Research Activity:

A class discussion on what sorts of changes we go through after birth, through adolescence to adulthood, ie growth in stature, hair growth/loss, sexual maturity, allometric growth of head vs limbs, changes in voice, gain/loss of strength, ,etc.

Define the term aging for students.

Is there a "fountain of youth"?; that is, can anything slow the aging process - exercise, diet, genetic therapy, etc. Why are people living longer now? A good class discussion could be developed around this historical quest.

Separate students into groups and have them research this topic. Have each group report back to the class.

Suggestions for Assessment

Knowledge

12.4.1-12.4.3
Written test/Quiz
- Summarize developmental changes in humans
- Define aging
- Describe factors that can contribute to aging

Skills and Processes

12.4.1-12.4.3
Research Activity:
- Written/oral report
- Participation in Class Discussion

Other Assessment

Journal Entries

Concept Mapping

Cooperative Learning

Suggested Learning Resources

Print

Texts

Biology: A Systems Approach
Chapter 26 - page749

Biology of Ourselves

Biology: The Study of Life

Nelson Biology
Chapter 22 - pages 542-544

Biological Science: An Ecological Approach

Multimedia

Chapter Five

Summary, Recommendations, and Conclusions

Summary of Pilot Teacher Training/Feedback Sessions

Three training/feedback sessions were held in the first semester of the 1995-96 school year with the Biology 30S pilot teachers. These training sessions were conducted by me and two other development committee members. The first of these sessions was two days in length and occurred in late August. The first day focused on the rationale, philosophy, instructional design, and scope and sequence of the new 30S/40S curriculum. Copies of each of the recommended text resources were distributed. The second day provided information related to differentiated instructional strategies with the distribution of the *Senior Years Science Resource Manual.* This manual described the processes involved in implementing differentiated instruction and provided some examples of exercises. Most of the day allowed for teachers to work in cooperative groups to develop "unit plans" based on the new 30S course. Each of the groups shared their plans in a large group setting later in the day.

All pilot teachers were extremely enthusiastic about the new curriculum and appreciated the approach utilized in the second day of training. However, some concerns were raised related to the quantity of content still remaining in the new 30S course. While the entire unit on *Cell Biology* (currently in 30S) was now in Science 20S, three new smaller units had been added to the new 30S course. These new units were *Energy for Life Processes, Blood and Immunity, and Support and Locomotion.* It was explained to pilot teachers that the entire curriculum had been restructured with different foci. Also, differentiated instructional strategies were being utilized to achieve outcomes

which may have been traditionally achieved through didactic instructional methods. Concerns were then raised around the lack of experience of most of the teachers in implementing these new strategies. Teachers were encouraged to attempt these new strategies and identify approaches that worked in their classroom as well as approaches that didn't work. It was stressed that this was all part of the field testing process.

The second training/feedback session with pilot teachers occurred in mid-October. The first portion of the day was focused on feedback related to the first five units of the curriculum and further unit planning related to units six through nine. It was expected that the semestered pilot schools would be approximately one third of the way through the course by this time. Most teachers were not as far along as anticipated as the majority of the teachers had only finished three or four of the first five units. This was attributed to a number of possible factors. In particular, timelines were underestimated by committee members, teachers needed more training in implementing differentiated instruction, some schools do not allow the recommended instructional time for high school courses, teachers were going too "deeply" in some topic areas and spending more time than necessary. It was decided to wait until the next training session before drawing any conclusions.

The cooperative groups from the first training session were asked to prepare feedback on the units they had taught to date. Feedback related to the curriculum material was quite positive, although most teachers stated that there was a "trade-off" between the coverage of the content and the implementation of all of the suggested differentiated instructional strategies if timelines were followed. There were also concerns raised about the nature of the unit on *Energy for Life Processes*. Most teachers felt that it was difficult to cover the topics of cellular respiration and photosynthesis on a

superficial basis and student interest in this unit was very low.

The concerns raised at the first training session about the lack of experience with differentiated instruction resulted in arrangements being made to allocate the last session of the day to training in this area. A specialist in differentiated instruction in science education was brought in to deliver a mini-workshop to the pilot teachers. Teachers were very positive about the training and thought that it would help them with the implementation of the remainder of the curriculum.

The third training/feedback session occurred in early December of 1995. The structure of the session was similar to that of the second session, although based upon evaluations from the previous session, more time was allocated to training in differentiated instruction. Unfortunately, the day was shortened somewhat by bad weather. As in the second session, it became quite apparent that the majority of teachers were not able to keep within the timelines allocated in each of the units.

The teachers who were attempting to follow the suggested instructional strategies felt that their students were gaining a much better understanding of the material and showing a greater interest in the subject matter. However, most teachers indicated that these activities require more time than was allocated. As a result, they were having to make choices around what topics to cover. The teachers who were attempting to keep within the timelines allocated were resorting back to traditional didactic methods of instruction in order to "cover" all the outcomes.

A final feedback session is scheduled for mid-February, at which time all of the semestered schools will have completed the course. This final session will allow teachers to provide their summative evaluation of the program and make recommendations for changes. In response to the concern over the excess content, pilot

teachers have been asked to provide an outline of content which could be eliminated. In addition, the teachers will have an opportunity to submit their daily journals, notes, and annotated curriculum documents. It is expected that these documents will form the basis for curriculum revision prior to second phase pilot.

Recommendations for Phase 2 Field Testing

The following are recommendations for revisions to the phase 1 Biology 30S curriculum and strategies for phase 2 field testing based upon the results of phase 1 pilot teacher feedback:

1. The amount of content in the curriculum must be reduced.

During the development process, an attempt was made to reduce the amount of content in the existing curriculum. However, this process became very difficult as each member on the committee thought it was critical to include certain topics. It was anticipated that the elimination of *Cell Biology* from the course would alleviate some of the time constraint pressures. However, as the committee attempted to integrate some of the new and interesting optional topics into Human Biology, the course became "content heavy" once again.

The majority of pilot teachers have indicated that it is virtually impossible to "cover" all of the learning outcomes outlined in the curriculum if differentiated instructional strategies are followed. Pilot teachers have also stated that student response to differentiated instruction has been extremely positive. Thus, it would appear that some of the content must be sacrificed for more meaningful learning activities. The data submitted from pilot teachers must be considered when decisions are made by the

curriculum committee around what topics can be eliminated and what topics must be retained.

2. The unit on *Energy for Life Processes* must be revised.

This unit has been the most problematic in terms of implementation for the teacher and level of interest on the part of the student. The issue of whether or not to study cellular respiration and photosynthesis at the high school level has been a contentious one throughout the development process. The intention was to introduce the students to these processes in a "big picture" way so that they could understand the relationship of these processes to life itself. However, most teachers could not successfully implement this approach. It would appear that there are three options surrounding this unit; re-write the unit with more specificity for implementation, integrate the topics into other units in the 30S/40S course, or remove the unit from the 30S/40S program. Due to the time constraints surrounding the course, a logical solution would be to integrate the topics on *enzymes* and *ATP* into *The Chemistry of Life* and integrate the topics of *cellular respiration* and *photosynthesis* into the 40S course. The development committee will need to make the final decision regarding this issue..

3. The assessment strategies column of the curriculum must be revised.

The assessment strategies column of the phase 1 curriculum document was filled in as much as possible to reflect assessment techniques related to the differentiated instruction suggested. However, due to the lack of training and experience of both myself and the committee in these techniques, it was decided to update this column for phase 2 field validation based upon the results of phase 1 field validation.

Feedback from phase 1 pilot teachers reveals that most are using traditional methods of assessment for evaluating student progress. However, there are some pilot teachers who are utilizing some authentic assessment techniques such as portfolios and performance evaluations. A portion of time will need to be allocated in the final pilot teacher session to gain some concrete data on assessment relevant to the new curriculum. In addition, an assessment specialist will need to review the curriculum document and make recommendations for revision. Once this data is collected, the committee will need to consider how to revise the assessment column.

4. Biology teachers will need to be trained in differentiated instruction.

The feedback received related to the implementation of differentiated instruction has been very positive. Most pilot teachers indicated that their students were gaining a better understanding of the course material with the use of these methods. However, it became apparent that the distribution of a resource manual related to differentiated instruction was not enough and further training was needed in order to bring the pilot teachers to a level where they would feel comfortable in implementing some of these strategies. The training component appears to be critical in the successful implementation of this curriculum.

Although the curriculum development committee has limited control over the issue of training, they should make a formal recommendation to the Department of Education and Training that formal training in differentiated instruction be provided to all biology teachers prior to implementation of the new program. This includes the phase 2 pilot teachers.

5. Multimedia resources will need to be integrated into the curriculum.

A section in the resource column in the curriculum guide has been left open for multimedia integration. Most of the pilot teachers expressed great interest in implementing multimedia resources such as CD-ROM, videodisc, and the Internet into the new curriculum. The *Curriculum/Multimedia Integration* program has the task of cross referencing appropriate multimedia resources to the new curriculum outcomes and modifying the existing instructional strategies and assessment strategies as they relate to the multimedia integration.

The new multimedia integrated curriculum components should be integrated with the phase 2 pilot document and appropriate training sessions held prior to field testing.

6. A resource manual should be compiled to support the new curriculum.

Pilot teachers indicated that they appreciated the opportunity to meet with their colleagues in the context of the training meetings in order to share information about their teaching of the new program. This included information about resources which were being utilized in the program. Many of the new resources which are cross-referenced in the new curriculum are not available to all teachers. These resources include labs, articles, and other activities. In addition, there are many good resources available which are currently being used by the pilot teachers and are not included in the curriculum document. Many of these resources were copied and distributed at the meetings. However, a formal process has not been established or initiated by the Department to make these available to all teachers upon implementation. There needs to be a mechanism by which these resources can be compiled for use by all teachers who wish to utilize them in their classroom.

Conclusions

The development process which has occurred over the last 15 months has been an extremely valuable experience for me from both a professional and academic perspective. Although I found the process frustrating at times, I learned that the process by which curriculum revision occurs is complicated, collaborative, and in many cases, compromising. I take particular satisfaction in seeing this document as it exists today. Although there is still much work to be done, this document has evolved from an initial "fuzzy" mandate to something which I feel is a very good model of the direction in which science curriculum should be moving.

Throughout the development and field testing process, I found myself evolving through a cycle of change. As I began to review the literature concerning science education reform, I was somewhat skeptical of the changes which were being recommended. I thought that I was a good biology teacher. I used primarily didactic teaching techniques such as lecture and demonstration, although when time allowed, students did become actively involved in scheduled lab work and field studies. I also thought that the curriculum guides produced by Manitoba Education and Training must be based on proven pedagogy, and therefore, I had no reason to question them. I modeled my teaching on the "good" teaching that I received as a student. I never really seriously questioned whether those methods were the best to achieve student learning.

As I reflected back to what I learned through high school and university science courses, I soon realized that I really hadn't retained most of the information that was presented to me. The information which I had retained had some sort of personal meaning to me and was grounded in experiences where I was actively involved in the subject matter. This reflection process caused me to question whether the strategies that

I used in my classroom were the best for my students. It also caused me to question whether the curriculum guides I was using were pedagogically sound. In most cases, I used didactic strategies in order to cover the amount of content outlined in the curriculum. There was always that pressure related to "covering" the curriculum.

Throughout the curriculum development process, I learned that most biology teachers were in a similar time-constrained situation as I was while teaching biology. This trend indicated to me that there must be a problem with our existing curriculum. If we, as a committee wanted to initiate change at the classroom level, we needed to address those problems. Some content expectations needed to be traded off for high quality instruction in science processes and skill development, for the development of general principles or themes, and for developing the relationship to the real world. Much more time needed to be made available for hands-on active learning. We needed to address the important concepts and issues and allow students the opportunity to make connections to their existing conceptual frameworks by pursuing topics which are relevant to them.

I think we have a lesson to learn from elementary teachers. They have been using most of the differentiated instructional strategies that we are attempting to implement at the high school level for some time now. I believe that we as high school teachers and curriculum developers used to think that we were above that level and that we were teaching our students in the best way possible. I have now changed my thinking and believe that we have a responsibility to ensure that the curriculum we deliver is designed in a way that students will actually learn what is intended. This does not mean that they are able to regurgitate information on short answer tests, but does mean to show evidence that they really understand the concepts and can relate those concepts to real world contexts.

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